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Austria

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12. ABSTRACT (Maximum 200 words)
This is the final report for the first International Congress for the Assessment of Stress Intensity and Stress Compatibility in Large Groups held November 25-27, 1999, in Bad Radkersburg, Germany. The report includes the list of attendees; the program, abstracts of presentations and related published papers. The majority of presentations deal with the effects of magnesium in stress.
Presentation titles include:
Effects of bed rest on sympathoadreanal and hormonal responses to various physiological stimuli.
Occupational stress in patients with chronic cardiovascular and metabolic disorders.
Serological alterations due to sauna baths with and without Mg supplement.
Stress assessment at wine and rock festivals, roles of blood gases and electrolytes.
Stress reactions in gerontology are dependent upon individual base values and Mg-dynamics.
Quantitative correlations between alteration of serological stress factors and pyschological test-scores.
Combined serological and psychological assessment of anxiety in bungee jumpers.
Hypothesis regarding potential injury of the endothelium of the normal heart complicating prolonged space missions.

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International Congress

For The Assessment Of Stress Intensity And Stress Compatibility In Large Groups

Bad Radkersburg, November 25th - 27th

THE ORGANIZERS OF THE CONGRESS

B. Bammer, W. Gollner, M. Hasiba-Gruber, B. Poncza,
B. Porta, S. Porta and W. Temmel

ARE DEEPLY INDEBTED TO THE FOLLOWING
ORGANIZATIONS FOR THEIR GENEROUS CONTRIBUTIONS:

US AIRFORCE
EUROPEAN OFFICE FOR AEROSPACE RESEARCH AND DEVELOPMENT
GOVERNMENT OF STYRIA
TOWN COUNCIL OF BAD RADKERSBURG
MARKTGEMEINDE KLÖCH
AVL – LIST GMBH
STARZINGER GMBH
TOURISMUSVERBAND BAD RADKERSBURG
KURHOTEL IM PARK

PROGRAM

INTERNATIONAL CONGRESS FOR THE ASSESSMENT OF STRESS INTENSITY AND STRESS COMPATIBILITY IN LARGE GROUPS

Thursday, November 25th, 1999

1700
Opening Address by the Mayor of the Town of Bad Radkersburg, Mr. P. Merlini

17 15 – 18 00
Introductory Lecture:
SOME POSSIBILITIES FOR STRESS ASSESSMENT IN LARGE GROUPS (SAILAG)
Sepp Porta, *Ph.D., Professor of Endocrinology, Institute of General and Experimental Pathology, University of Graz, Head, Institute of Applied Stress Research, Bad Radkersburg, AUSTRIA.*
co authors: T. Gifford, USAFA, J. Rand, USAFA, D. Westmoreland, USAFA
18 00
Welcome Dinner

Friday, November 26th, 1999

07 00 – 08 00
Breakfast

0800 – 10 00
Session: Theory and Application of SAILAG (Coordination: M.S. Seelig)

EFFECTS OF BED REST ON SYMPATHOADRENAL AND HORMONAL RESPONSES TO VARIOUS PHYSIOLOGICAL STIMULI.
H. Kaciuba – Uscilko *Ph.D., Professor of Physiology, Polish Academy of Sciences, co-authors: K. Nazar, J. Smorawinski (20 min)*

OCCUPATIONAL STRESS IN PATIENTS WITH CHRONIC CARDIOVASCULAR AND METABOLIC DISORDERS
K. Nazar *M.D., Professor of Physiology, Polish Academy of Sciences, co-authors: H. Kaciuba-Uscilko, E. Wojcik-Ziolkowska, B. Kruk. (20 min)*

SEROLOGICAL ALTERATIONS DUE TO SAUNA BATHS WITH AND WITHOUT MG SUPPLEMENT.
W. Marktl *M.D., Professor of Physiology, University of Vienna, Head, Ludwig Boltzmann Institute for Biorhythms, Bad Tatzmannsdorf.*
co authors: W. Temmel, G. Pracher, S. Porta (20 min)

STRESS ASSESSMENT AT WINE AND ROCK FESTIVALS, ROLE OF BLOOD GASES AND ELECTROLYTES
K.H. Smolle, *M.D., Head of Intensive Care Unit, 1st Department of Medicine, State Hospitel Graz (15 min), Sascha Doder, M.D. Head Physician, Angiologist*

STRESS REACTIONS IN GERONTOLOGY ARE DEPENDENT UPON INDIVIDUAL BASE VALUES AND MG - DYNAMICS
G.Pinter, *M.D, Head Physician, Department Of Medical Gerontology, State Hospital Klagenfurt*
Co authors: Palasser, H. Wieltschnig (15 min.)

GENERAL DISCUSSION

10 00 – 10 30
Coffee Break

10 30 – 11 30
Combined Serological – Psychological Methods for SAILAG
(Coordination: H. Kaciuba - Uscilko)

QUANTITATIVE CORRELATIONS BETWEEN ALTERATION OF SEROLOGICAL STRESS FACTORS AND PSYCHOLOGICAL TEST – SCORES.
W. Temmel, *M.D., Institute of Applied Stress Research, Bad Radkersburg*
Co authors: M. Weger, S. Porta (15 min)

COMBINED SEROLOGICAL AND PSYCHOLOGICAL ASSESSMENT OF ANXIETY IN BUNGEE JUMPERS
G. Fleck, *Ph.D., Head Psychologist of the Airforce Division of the Austrian Federal Army*
Co author: B. Hueber (20 min)

COMBINED SEROLOGICAL AND PSYCHOLOGICAL ASSESSMENT OF ANXIETY IN ANXIETY PATIENTS.
A. Kogler, *Ph.D., Institute of Psychosomatics,Graz, Scientific Journalist (15 min)*

11 30 – 13 00
Substitution 1 (Coordination: L.M. Castell)

IMMUNODEPRESSION AND THE ROLE OF SOME AMINO ACIDS.
Linda M. Castell, *Ph.D.,Cellular Nutrition Research Group Supervisor,*
University Department of Biochemistry, Oxford
Co authors: N. Osei, E.A. Newsholme. (20 min)

METABOLIC STRESS OF TERRESTRIAL HIGH ALTITUDE
M. Damian Bailey *PhD, Hypoxia Research Unit, Health and Exercise Sciences Research Laboratory, University of Glamorgan, S.Wales, UK. (20 min)*

BEHAVIOUR OF MG IN PATIENTS DURING RECREATION FROM EXTENSIVE LIVER SURGERY
H. Bacher, *M.D. Professor of Surgery, 1st Surgical Department, University of Graz, Medical School.(15 min)*

TRADITIONAL AND NEW ASPECTS OF THE BIOCHEMISTRY OF MAGNESIUM
H. Zollner, *Professor of Biochemistry, Institute of Biochemistry, University of Graz (20 min)*

12 30 – 14 00
Lunch break

14 00 – 16 00
Substitution 2 (Coordination: K. Nazar)

STRESS REACTIONS IN MAGNESIUM DEFICIENCY
Mildred S. Seelig, *M.D, Master of American College of Nutrition, Prof. of Nutrition, Univ. of NCarolina (30 min)*

HYPOTHESIS REGARDING POTENTIAL INJURY OF THE ENDOTHELIUM OF THE NORMAL HEART COMPLICATING PROLONGED SPACE MISSIONS
William J. Rowe *M.D. Em.Professor, (30 min)*

THE ROLE OF SOME AMINO ACIDS IN POST OPERATIVE FATIGUE AND IN CHRONIC FATIGUE SYNDROME.
Linda M. Castell, *Ph.D.,Cellular Nutrition Research Group Supervisor,*
University Department of Biochemistry, Oxford.
Co authors: J. Phoenix, T. Yamamoto, J. McGuire, E.A. Newsholme (20 min)

COLD EXPOSURE AND SLEEP DEPRIVATION – CATECHOLAMINE- MAGNESIUM INTERACTION
Sepp Porta, *Ph.D., Professor of Endocrinology, Head,Institute of Applied Stress Research, Bad Radkersburg, Institute of General and Experimental Pathology; University of Graz, AUSTRIA. (15 min)*

Poster Presentations (case studies):

1 POST STRESS PROVOCATION TEST WITH AN ANORECTIC PATIENT
F. Boehmer, *MD,Head of Department, Sophienhospital, Vienna*
Co author: S. Porta

2 SEROLOGICAL AND PSYCHOLOGICAL ASSESSMENT OF A SEXUAL VIOLATOR UNDER FORCED PSYCHOTHERAPY.
A. Kogler, *Ph.D., Institute of Psychosomatics, Scientific Journalist*
Co author: S. Porta

1600 – 1700
Coffee Break,

During coffee break some information about an intended common statement

Suggestions to all manufacturers of magnesium electrodes:
National consensus about high and low margins of ionized serum magnesium are less important, as long as multinational manufacturers do not agree about calculation quotients or modes of comparison between their products, whereby increased stress upon the diagnostical value of magnesium dynamics could be helpful. Such an agreement would immediately increase acceptance of the measurement of ionized magnesium; scientists and manufacturers would profit. Any suggestions along those lines would be helpful. We plan to coordinate them and send them for publication in form of a communiqué at least to Magnesium Bulletin.

From 17 00 to 19 00: Swimming, walking, recreation, enjoying thermal wells a.s.o.

19 00 Congress Dinner. Address by State Treasurer Ing.H.J. Ressel
during Dinner: Degustation of Local Champagne (formerly appointed by the Austrian Emperor),
Degustation of world famous "Klöcher Traminer" white wine

Saturday, November 27th, 1999

07 00 – 09 00
Breakfast

09 00 – 10 00
Resume of congress, consensus for the communiqué, signing of the communiqué (will be published in the December - issue of "Magnesium Bulletin", concluding remarks)

10 00 – 12 00
End of congress with informal coffeeklatsch, selfmade local cakes and sweets.

In lieu of a congress motto:

Just recently, the ***"Kurhotel im Park",*** *where the meeting will be held, has been awarded a much sought after commendation for exceptional food by the French testers Gault – Millot.*

ENJOY!

List of Congress Attendees

	NAME	AFFILIATION
1	Bacher, Prof. Dr.	***Prof. of Surgery, 1st Surg. Dept., University Med. School***
2	Boehmer Dr.	***Med. Head of Sophien - Hospital, Vienna***
3	Bradshaw Dr.	***Lieut. Col., USAF, Office of the US Surgeon General***
4	Bruggraber, DI	***AVL GmbH***
5	Castell Dr.	***Supervisor, Cellular Nutrition Research Group, Univ. Dep. of Biochemistry, Oxford University, U.K.***
8	Damian Miles Bailey Dr.	***Hypoxia Research Unit, Health and Exercise Research Unit, Univ. of Glamorgan, Wales, U.K.***
7	Fleck Dr.	***Head Psychologist, Austrian Air Arm***
8	Frise Dr. Brig. Gen.	***Head, Psychological Service of the Austrian Army***
9	Harer, Dr.	***AVL GmbH***
10	Hueber, Mag.	***Psychologist,***
11	Kaciuba-Uszilko Dr.	***Prof. of Physiology, Polish Academy of Sciences, Applied Physiology.***
12	Kim, Seeung Wong.	***Colonel, Korean Defense Attache in Austria***
13	Kogler, Dr.	***Psychologist, Institute of Psychosomatics, Graz.***
14	Kollmann, Dr.	***Hofrat, Bundesanstalt für Geologie, Head, Dep. of Hydrogeology***
15	Larsson Dr.	***M.D.***
16	Marktl Dr.	***Prof. of Physiology, Physiol.Dep.,Univ. of Vienna, Head, LB Instit.of Biorhythmics, Bad Tatzmannsdorf***
17	McMain, Mr.	***Businessman***
18	Nazar Dr.	***Prof. of Physiology, Polish Academy of Sciences, Applied Physiology.***
19	Palasser Dr.	***Head Physician, Gerontology, State Hospital Klagenfurt***
20	Pfannhauser, Dr.	***Prof., Head of the Department of Food Chemistry, Technical University, Graz***
21	Pinter Dr.	***Head Physician, Gerontology, State Hospital Klagenfurt***
22	Porta Dr.	***Prof. of Endocrinology, Dep.Gen.Exp.Pathol.,Univ. of Graz, Head Inst.of Applied Stress Research, Bad Radkersburg***
23	Rowe Dr.	***Prof. of Medicine***
24	Seelig Dr.	***Prof., Univ. of North Carolina,***
25	Seidl Dr.	***Head Research Department of VERLA - Pharm, Tutzing, Germany***
26	Smolle, Dr.	***Head of Intensive Care Unit, 1st Medical Department, University of Gaz***
27	Temmel, Dr.	***MD., Institute of Applied Stress research, Bad Radkersburg***
28	Wieltschnig Dr.	***Head of the Gerontology Department, State Hospital Klagenfurt***
29	Zaruba	***Ministerial Counsillor, Austrian Ministry of Defense, Vienna***
30	Zollner, Dr.	***Prof. of Biochemistry, Department of Biochemistry, University of Graz***

List of Abstracts

SOME POSSIBILLITIES FOR STRESS ASSESSMENT IN LARGE GROUPS.

S. Porta T, Gifford, J. Rand, D. Westmoreland
Institute of Applied Stress Research
Bad Radkersburg, Austria
Institute of General and Experimental Pathology
University of Graz, Austria
3 Biology Department.
US Airforce Academy, Colorado Springs,

Catecholamine, especially norepinephrine determination for the assessment of stress is the classic method, but the hormone has an exceptionally short half life and is expensive to determine. One needs skilled personnel and molesting blood sampling. We could show (Porta et al. 1997), that some effects of catecholamines, like changes in base excess, are linearly proportional to catecholamine levels, and therefore could be used as screening parameters. By measuring 10 different, stress related parameters, we may be able to get a whole pattern of the effects of stresses of different intensity and duration in the more or less immediate past, combinining the post stress provocation test (Porta et al. 1991) with the measurement of interrelated catecholamine effects, whose proportionalities may change according to the kind or severity of stresses, thus characterizing them.

An Example:

Material and methods: Of 26 young volunteers on national service 50µl of capillary blood were taken just after light gymnastics and 3 minutes of jogging. Bicycle ergometry up to 200 watts (post stress provocation test, Porta et. al. 1993) was superimposed immediately, followed by a second blood sampling for determination of electrolytes, blood gases and lactate. A group of 20 more volunteers who did not undergo immediate previous stress, but sleep depriving night exercises followed by a field combat maneuver some hours beforehand, underwent the same procedure.

Most important results and conclusions: Ionized Mg was low in the first group and much higher in the second group, a feat not due to diet but to previous stress. Linear correlation between the parameters were the more plentiful, the higher the intensity of accumulated stress has been. Moreover, characteristic stress related interparameter correlation pattern (ICP) evolved, whereby Mg played an important role. Consequently, we formed 3 new subgroups, regardless of the previous workload, only characterized by the fact, of an increasing or decreasing or stable reaction of ionized Mg to the ergometric test. Average values, correlation numbers and ICPs pointed to the fact, that the increasing Mg group consisted mainly of subjects in a significant better bodily shape than in the decreasing group.

EFFECTS OF BED REST ON SYMPATHO-ADRENAL AND HORMONAL RESPONSES TO VARIOUS PHYSIOLOGICAL STIMULI

Prof. Dr. Hanna Kaciuba-Uscilko, Prof. dr.Krystyna Nazar, Prof. dr.Jerzy Smorawinski

Prolonged bed rest is applied by physicians to confine patients for health restoration. Besides, physiological responses to horizontal or head-down postures have been studied in healthy subjects as models of reactions to microgravity environment in astronauts. The recumbent position results in a loss of most hydrostatic pressure, elimination of longitudinal compression on the spine and long bones of lower extremity, reduced muscular force on bones, decreased total energy expenditure. The effects of bed rest on the autonomic nervous system and hormonal regulatory mechanisms are still the matter of discussion. The data are often controversial, since the studies covered various periods of bed rest and were often performed with very limited number of subjects differing in age, gender and physical fitness. The aims of the present study were: (1) to examine the effects of three days of bed rest on neuro-hormonal responses to such physiological stimuli as glucose ingestion, graded bicycle exercise, changing of body position (lying to standing), cold pressure test (hand cooling), and (2) to find out whether the level and kind of physical activity preceding bed rest modifies its effects. Twenty three young sedentary subjects, 18 endurance trained athletes (runners, cyclists and triathlonists) and 20 strength trained athletes (body builders and wrestlers) participated in the investigations. The study showed that 3 days of bed rest (1) increase plasma insulin response to an oral glucose load (70 g), (2) decrease plasma noradrenaline (NA) level under basal conditions (in supine subjects after overnight fast), (3) diminish the plasma catecholamine responses to an oral glucose load and to 8 min standing, particularly in endurance athletes, (4) cause an earlier activation of the sympathetic nervous system during graded exercise test only in the endurance trained subjects, (5) does not influence catecholamine response to the hand cooling (2 min), (6) increase resting plasma renin activity and its response to standing and exercise, (7) decrease resting and exercise plasma growth hormone concentration. It is concluded that remaining recumbent for only three days can modify neural and endocrine responses to various physiological stimuli, especially in previously physically active men.

OCCUPATIONAL STRESS IN PATIENTS WITH CHRONIC CARDIOVASCULAR AND METABOLIC DISORDERS

Prof. Dr. Krystyna Nazar, Prof. dr. Hanna Kaciuba-Uscilko, dr. Ewa Wojcik-Ziolkowska, Prof. Dr. Barbara Kruk

Hypertension, coronary heart disease (CHD), and obesity occur in approx. 20% of middle aged men employed in a wide variety of work settings. Laboratory investigations revealed that the patients are more susceptible to physical and mental stress than healthy persons. Since the stress responses may lead to aggravation of their health status it is of importance to evaluate the impact of psychosocial work conditions on the time course of blood pressure and cardiac function indices in patients engaged in jobs with high mental demands and extensive responsibility. In the present study 80 patients with hypertension and/or CHD, aged from 35 to 65 years, were recruited from the Outpatient Cardiac Unit for Diagnosis and Therapy, MRC. They are full time employed as business managers, school or university teachers, lawyers, medical doctors, research workers etc. The type of behavior of the patients (type A and B) and conditions of their work were assessed by using respective questionnaires. During 4 separate week days ambulatory blood pressure and electrocardiogram were recorded for 24 hours using Holter methods. The patients were asked to choose two more and two less stressful days, and to make notes of their activities and events during each of these days. The patients' mood status during work time was evaluated on the basis of ad hoc mood questionnaire. The pharmacological treatment was not discontinued. For assessment of the patients' stress reactivity the standardized laboratory testing program was elaborated. It includes cardiovascular and hormonal responses to mental stress (arithmetic Kreapelin test), exposure to noise, static hand-grip, and orthostatic maneuver.

By gathering these data interventions can be planned to attenuate the effects of occupational stress on health status of vulnerable employes with chronic cardiovascular and metabolic diseases.

This study is supported by the Strategic Governmental Program "Safety and Health Protection of Men in Work Environment", grant no 04.10.6.

STRESS ASSESSMENT AT WINE- AND ROCKFESTIVALS, ROLE OF BLOOD GASES AND ELECTROLYTES.

Sascha Doder and K.H. Smolle

Wine festivals:

Magnesium loss as a consequence of chronic alcoholism has been described i.a. by .Elisaf et al. 1995 who even postulated a central role of magnesium in the homeostasis of other electrolytes in alcoholic patients. Altura et al. 1996, saw a biphasic effect during acute ethanol perfusion upon heart muscle, ascribing a beneficiary action to low doses of ethanol. On the other hand, interpretation of blood levels of total magnesium or its ionized and bound subfractions depends upon whether ist source is dietary or stress (ethanol?) induced (Porta et al. 1993). Therefore we measured blood gasses, electrolyte and lactate concentrations in correlation to the concomitant blood ethanol levels in attendees of a " Kloecher - Traminer" wine festival.

32 male and female attendees were checked for blood ethanol concentration (BEC). Simultaneously, 300 µl of capillary blood were taken to determine lactate, pO2, O2sat, pCO2, CO2sat, pH and BE (AVL compact 2 blood gas analyzer) and ionized Mg, Ca and Na (AVL 988-4.) Regardless of their BEC the attendees were asked to carry on according to their pleasure and return after 30 minutes for a second check.

Group results:

Results and Discussion:

Wine uptake leads to dramatic fall in pH which increases again after about 0,5 permille of ethanol.

Other stress parameters like e.g. pO2 and lactate show a similar biphasic behaviour, so that "pseudonormal" values along with increasing intoxication could be seen.

Electrolyte loss in the ratio: Na:Ca:Mg = 1:2:4 occured only in appreciable amounts beyond the 1 permille limit.

Rock festivals:

42 attendees of a rock- and hip-hop festival were checked for electrolytes, blood gases and lactate, whether those alterations would correlate with Mg alterations. 60 minutes after the first check the probands were asked for a second check. Eventually it turned out, that the most severe stresses were neither emotional, nor ethanol related exertions, but heat stress. Most important results: A temperature drop about 8 p.m.(from320C to 180C) leads to a significant increase in BE values from -3,76 to -2,59 mmol/l ($p<0,0001$). This was accompanied by a significant fall in ionized Mg from 0,71 to 0,53 mmol/l ($p<0,0001$). Furthermore, not unlike our experiments with ethanol uptake, basal ionized Mg correlates negatively and highly significantly with DMg ($r = -0,558$) and positively with ionized Mg levels 60 min. later ($r = 0,529$), provoking inversion of Mg- dynamics. Ca in its turn is not influenced by temperature alterations and shows no correlations

where Mg does. Again it could be shown, that measurement of ionized blood Mg along with blood gases and lactate during stress most definitely has its merits.

STRESS REACTIONS IN GERIATRIC GYMNASTICS DEPEND UPON BASAL VALUES AND SERUM MAGNESIUM DYNAMICS

G. Pinter, A. Palasser, H. Wieltschnig.
Department for Medical Geriontology, State - Hospital Klagenfurt Austria

27 senior citizens absolving ambulant gymnastics therapy were checked for catecholamines, bloodgases and electrolytes by blood sampling from an antecubital catheter before and after light gymnastics.

The participants of the test have not been under stationary therapy for at least 3 months.

Results and discussion:

1. the higher norepinephrine basal values, the greater are their alterations due to workload. The same holds true even for their effects, like BE or pO2 alterations.
2. Sorting the patients according to increasing, stable or decreasing serum magnesium, it turned out that the increasing magnesium group mostly had low catecholamine basal values, and a significant better coping with stress.
3. The basal values e. g. in the magnesium increasing group concerning BE were significantly higher , pO2 was significantly lower than in other groups. Alterations in HCO3 and pO2 were significantly less pronounced

QUANTITATIV CORRELATIONS BETWEEN ALTERATION OF SEROLOGICAL STRESS FACTORS AND PSYCHOLOGICAL TEST-SCORES.

W. Temmel 1,2, M. Weger 1, S. Porta1,2, E. Frise 4, G. Fleck 4,
2 Institute of Applied Stress Research*, Bad Radkersburg
1 Institute of General and Experimental Pathology, University of Graz
4 Psychological Service of the Austrian Armed Forces, Am Fasangarten 2, 1130 Vienna, Austria

The interaction of catecholamines with changes in blood gases, electrolyte and carbohydrate metabolism in stress is qualitatively accepted but quantitatively unclear and most probably situation dependent. Therefore, mean values and correlative changes of such selected stress parameters in different stress types of human probands were investigated to determine quantitative relationships between parameters characterizing stress intensity and stress duration. Following the concept of additive catecholamine secretion in a so called ² post stress provocation test ², we superimposed a psychological reaction test (PRT) upon 3 days of extensive combat training. The reaction to such a standardized test before and after combat training should therefore elucidate the influence of combat training induced fatigue upon test performance. By comparing performance during the same test either before or after combat training, the influence upon participants, and therefore the intensity of combat training stress could be evaluated. Quantitative linear correlations should show eventual proportionalities between psychological score and serological alterations.

Materials and Methods

3 days of uninterrupted combat training of 16 male officer trainees of the Theresianische Militärakademie had to undergo a psychologically demanding test of approximately 45 minutes afterwards.Blood samples were drawn immediately before and after the psychological test series consisting of a signal detection test, followed by a visual discrimination test and a short memory test, altogether lasting 45 minutes. For internal individual standardization, the reaction of the same probands to the same tests was checked one week earlier, but without previous exercise.For statistical analyses the raw scores had been used, i. e., for each correct reaction one point was given (positive test score), and for each wrong reaction also one point was given (negative test score). The following serum parameters were measured :Free and total epinephrine, norepinephrine and dopamine, ionized magnesium, total serum magnesium, whereby the bound magnesium concentration was calculated by subtraction of the free magnesium subfraction from total serum magnesium levels; GT, GPT, GOT, urea ; creatinine, lactate dehydrogenase, sodium, potassium, ionized and total calcium,

chloride, amylase serum cortisol, WBC and differential blood count as well as mitogen stimulation and blood gases (pCO2, HCO3, pH, BE, pO2 and O2sat.).
By the way of internal standardization, the reaction of the same probands to the same tests was checked without previous exercise one week earlier.

Results and Discussion

From the 67 measured and calculated serum and plasma parameters, we decided to show those 15 that did show significant differences of their means before and after psychological testing.
Alterations of serum levels during the PRT without previous combat training correlated in four cases with the test score : As was the case with absolute values ,also here the most frequently seen significancies were those of magnesium parameters. The obvious difference between the behaviour of absolute and delta values is, that delta values never correlate with negative test scores.
The frequency of correlations of positive and negative PRT scores and serum delta values after previous combat training increased about sixfold. Similiar to the situation with absolute values many blood gas - PRT score correlations begin to evolve ; magnesium correlations vanish and a typical parameter for delta value correlations, catecholamines (which made their appearance in the delta correlations without combat) already begin to figure more prominently.
Evidently, we replaced the usual physical exertion of the post stress provocation test by a psychical reaction test.
If a larger number of correlations really could be taken as an increase of sensitivity towards superimposed stress, then both the psychological score and serological reactions to the post- stress provocation test may be a valid tool for the measuring of the remaining stress compatibility of a person who underwent previous fatigue.

COMBINED SEROLOGICAL AND PSYCHOLOGICAL ASSESSMENT OF THE DYNAMICS OF STRESS AND RECOVERY IN BUNGEE JUMPERS

Günther Fleck & Brigitte Hueber,
Military Psychology Service, Vienna, Austria

It is a well-known fact that strong affective-physiological arousal reactions provoked by different stressors will not end abruptly after the stressful episode is over, they rather need more or less time for recovering. People differ in their potential to recover from stressful experiences. The recovery potential of an individual may contribute to subjective well-being and health. In this field study an attempt is made to study the dynamics of stress and recovery of a very dramatic event: The bungee jump. This event was chosen since it contains the potential to produce strong stress reactions. The question to be examined was if people with a high actual state of well-being create less strong stress reactions before their bungee jump and show better recovery effects after the bungee jump than people with a low actual state of well-being. For this purpose people practizing their first bungee jump were asked to participate in the experiment. The subjects (N=23) passed serological as well as psychological assessments before their first bungee jump. The serological assessment contained pH, pCO2, Base excess, HCO3, pO2, O2, Na, Mg, Ca, and Glucose as indicators for biochemical stress reaction patterns. The psychological assessment had its focus on the actual state of well-being, i.e., the recovery-strain-state, measured by the Recovery-Stress-Questionnaire (Kallus, 1995). This instrument allows to assess two important areas of subjective well-being: The actual state of experienced strain, and the actual state of experienced recovery. Additionally, the subjects were asked to execute a short physical exercise immediately after the jump to reduce the provoked stress reactions and to enhance the recovery processes. After the physical exercise again the biochemical variables were measured. Two hypotheses were tested: I. Subjects with low strain values will develop weaker stress reactions before the first bungee jump than subjects with high strain values. II. Subjects with high values in recovery will recover better after the jump than subjects with low values in recovery. The first hypothesis could be partially confirmed: Subjects with actual low strain values differed significantly from subjects with actual high strain values at least in the parameters O2, pO2, pH and HCO3, but not in the other parameters. The second hypothesis could not be confirmed: Subjects with actual high recovery values did not differ from subjects with actual low recovery values in any biochemical parameter.

COMBINED SEROLOGICAL AND PSYCHOLOGICAL ASSESSMENT OF ANXIETY IN ANXIETY PATIENTS

A. Kogler and M. Kogler

Anxiety disorders, especially panic attacks can be artificially evoked by several substances, some of them so called „metabolic panickogenes" like lactate, CO2 and HCO3. They alter pH values , stimulate breathing frequency and thus create a model for panic attacks. Another group of substances involves the noradrenergic and serotoninergic system. They partly act via the Hypothalamic - Hypophyseal - Adrenaocortical System (HPA). This group of substances may be seen as a model for the generalized anxiety disorder. The panic and anxiety creating potency of both groups is well investigated. Much less is known about the metabolic and noradrenergic/serotoninergic situation of patients at the beginning of psychotherapy, whose anxiety disorders are not provoked by those substances.

Therefore our study investigates how changing patterns of lactate, baseexcess, CO2, HCO3, pO2, electrolytes a.s.o. do differ between each other, according to differing provocations (physical workload, biofeedback, relaxation) in anxiety patients and control persons. According to the ability of additive secretion of catecholamines, striking differences between cumulating catecholamine effects (see above) in anxiety patients and control persons due to the same sort of provocation could be seen.

IMMUNODEPRESSION AND THE ROLE OF SOME AMINO ACIDS

L. M. Castell and E. A. Newsholme
Cellular Nutrition Research Group, University Department of Biochemistry, Oxford OX1 3QU, U.K.

There is considerable evidence that glutamine is "conditionally" essential, and is an important fuel for some key cells of the immune system. In athletes undertaking prolonged, exhaustive exercise, such as a marathon, there is a 20-25% decrease in plasma glutamine after the race, at the same time as immunodepression occurs. It is suggested that the decrease, which remains low for about 4-6 hours, may affect the ability of some immune cells to function optimally. Thus, for several hours after a race, athletes may be vulnerable to opportunistic infections. Data from several marathon studies have shown a decrease in the incidence of infections in athletes taking glutamine compared with those taking placebo, as well as an effect on some aspects of immune function (Castell et al., 1996).

Evidence that both parenteral and enteral glutamine feeding can have beneficial effects comes from several clinical studies. In particular, there is evidence that glutamine feeding not only has a beneficial effect upon gut function but also upon the immune system. Findings include decreased incidence of infections and increased T-cell recovery in bone marrow transplant patients, and enhanced T-cell response in patients undergoing surgery or suffering from acute pancreatitis. Studies on animals include findings of increased alveolar macrophage phagocytosis, reversal of biliary IgA suppression, and increased numbers and function of lymphocytes during sepsis.

More recently, supplementation of the branched chain amino acids (BCAA) has been shown both to maintain the plasma concentration of glutamine in athletes, and to reduce the incidence of upper respiratory tract infections (Bassit et al., 1999).

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THE METABOLIC STRESS OF TERRESTRIAL HIGH ALTITUDE

Dr Damian Miles Bailey PhD,
c/o Hypoxia Research Unit, Health and Exercise Sciences Research Laboratory,

University of Glamorgan, S.Wales, UK. CF37 1DL

The aims of the present investigation were to determine the physiological implications of acute mountain sickness (AMS) and establish constitutional risk factors which may be important in its pathogenesis during a mountaineering expedition to Mt Kanchenjunga (K3). We specifically concentrated on the independent roles of free radical mediated oxidative stress, branched chain amino acid (BCAA) metabolism and the hormonal regulation of satiety at high altitude. It was hypothesised that the oedema and hypoxaemia induced by AMS could be ascribed to a systemic inflammatory response secondary to an infection and/or free radical mediated vascular damage. Nineteen apparently healthy male mountaineers aged 38 (mean) ± 12 (SD) volunteered for the study. A variety of measurements were determined at rest and following a cycling test to volitional exhaustion before (SL1) and shortly after (SL2) a 7 ± 5 days stay at K3 base-camp (BC) which was established at ~5100 m. Resting overnight fasting venous blood samples were obtained on the morning of the second day at BC. The ascent to BC lasted 20 ± 5 days and with the exception of 5 rest days, each ascent day involved 250 ± 44 min of brisk walking at 68 ± 5% of the group's predicted maximal heart rate. All subjects refrained from taking any medication recommended for AMS prophylaxis. The prevalence and severity of AMS quantified using established criteria increased during the ascent trek and sojourn to BC. Sixty percent of the group experienced AMS (defined as a mean symptom score ^{3} 2 points) during the first two days at BC and one subject was evacuated to Kathmandu with suspected HACE. Maximal oxygen uptake (O2MAX) decreased from 3.44 ± 0.93 L.min-1 (SL1) to 1.80 ± 0.28 L.min-1 at BC ($P < 0.01$ v SL1) and increased to 3.05 ± 0.53 L.min-1 at SL2 ($P< 0.01$ v BC). Selected myofibre proteins indicative of skeletal muscle damage (total phosphocreatine activity, myoglobin), lipid peroxidation "footprints" (lipid hydroperoxide and malondialdehyde) and plasma cholecystokinin (metabolic marker of satiety) were shown to increase at altitude. There was a marked increase in the incidence and severity of infectious illnesses encountered and a subsequent decrease in the plasma concentration of glutamine and BCAA. The more physically-conditioned subjects at sea-level (presenting with the highest lactate threshold) seemed to be more prone to contracting an infection and AMS at high altitude. A relationship was observed between AMS score at BC and the following; magnitude of arterial desaturation during physical exercise ($r = 0.73$, $P < 0.05$) and the increases (BC-SL1) in total CPK ($r = 0.57$, $P < 0.05$) and lipid hydroperoxide ($r = 0.61$, $P < 0.05$). Subjects diagnosed with AMS presented with a greater increase in total serum CPK activity,

myoglobin and lipid hydroperoxide concentrations and a greater decrease in BCAA concentration.

These data indicate changes in the structural integrity of skeletal or cardiac muscle cell membranes at high altitude due to physical activity and/or environmental hypoxia. We have also identified a decrease in arterial distensibility (a surrogate measure of endothelial function) shortly following return to sea-level providing further evidence of vascular dysfunction (unpublished data). The source of membrane damage, which was more pronounced in those subjects presenting with AMS, may be linked to an increased activity of oxygen free radicals (OFR). Whether increased susceptibility to membrane damage at altitude due to a deficient antioxidant defence system is the cause or consequence of AMS remains to be elucidated in future studies.

The incidence of infections, confined predominantly to the upper respiratory and gastrointestinal tracts were more prevalent at high altitude. The decrease in plasma glutamine, a conditionally essential amino acid required for optimal lymphocyte proliferation and macrophage phagocytosis, may have increased the mountaineers' susceptibility to opportunistic infections. The subsequent release of vasoactive inflammatory mediators may be implicated in the pathogenesis of oedema which would exacerbate arterial hypoxaemia; physiological phenomena which could account for at least some of the debilitating symptoms ascribed to AMS. We are currently conducting a double-blind placebo-controlled glutamine supplementation study in the Himalayas to further explore the link between infection and susceptibility to AMS.

Two unique observations may also contribute to our understanding of the mechanisms implicated in the cachexia frequently observed during a high altitude expedition. The observed increase in the gut hormone CCK represents the first hormonal evidence for impaired satiety at altitude. Alternatively, the catabolic effects of hypoxia, previously considered a maladaptive response, may well be of functional significance, more specifically by improving immunoreactivity. The major source of nitrogen for glutamine formation are the BCAA, their metabolism being largely confined to skeletal muscle. The observed decrease in serum BCAA concentration may signal for the endogenous catabolism of skeletal muscle to provide a constant supply of BCAA and thus glutamine; the latter amino acid required as a substrate for lymphocytes and macrophages during more active immunosurveillance.

The use of AMS prophylactics such as acetazolamide which functions as a respiratory stimulant by inhibiting carbonic anhydrase have become increasingly popular amongst mountaineers. Our findings also suggest a role for amino acid and antioxidant supplementation at high altitude which, via different mechanisms, may also decrease individual susceptibility to AMS.

BEHAVIOUR OF MG IN PATIENTS DURING RECREATION FROM EXTENSIVE LIVER SURGERY

H. Bacher,
M.D., Professor of Surgery, 1st Surgical Department, University of Graz, Medical School.

The aim of our study was to assess the influence of intraoperative hypoxic stress - unavoidably brought about by so called Pringle maneuver - on free and conjugated catecholamines during major hepatic resection. Judging from earlier results of fatigue-experiments in rats we also wanted to check the relationship between poor general preoperative condition and conspicuously low triglyceride serum concentrations as well as the behaviour of serum magnesium. The study included 26 patients with primary and secondary liver tumors. The mean age was 54 years (range 27-79). Twenty-one patients had segmental liver resections, 3 had hemihepatectomies and 2 hydatid cysts were treated by cystectomy. Blood samples were taken 2 days before and throughout surgery. Catecholamine plasma values were determined by high performance liquid chromatography. Statistical comparisons were made by t-test, ANOVA and chi square test. Free plasma catecholamines increased significantly during prolonged intraoperative ischemia (Pringle time 50-125 minutes). Patients with elevated intraoperative catecholamines had a significant correlation to postoperative episodes of tachycardia, and prolonged hospital stay. On the other hand, we could also see postoperative tachycardias in patients with short Pringle times (18-49 minutes) but with decreased preoperative serum triglycerides as an indicator of chronic stress and reduced general condition. Intraoperative hypoxic stress is associated with increased catecholamine values. Elevated catecholamines may well cause postoperative sinus-tachycardias (mean 20 hours) and are strongly related to postoperative liver failure and prolonged hospital stay. Additionally, peculiar behaviour of Mg during recreation, dependent upon the different status of the patients was. seen, whereby drastic falls in Mg could be prevented by dopamine infusions. Since low Mg exerts well known reactions upon the heart, an additional possibility for the tachycardia is discussed.

BIOCHEMISTRY OF MAGNESIUM

H. Zollner
Institute of Biochemistry University of Graz

Magnesium is an ubiquitous element in nature; 2.1% of the earth crust is formed by magnesium. In the body it is the second most abundant cation second to potassium. 60% of the total magnesium (270-420 mg/kg body wt.) is localized in bone, 39% in soft tissue and the remaining 1% in extracellular fluids. Rat liver cells contain 23 nmoles/mg dry wt. 50% are found in the endoplasmatic reticulum, 20 % in mitochondria and the rest in cytosol. The major part (94%) of cytosolic magnesium is bound to proteins, membranes, nucleic acids and intermediary metabolites. 41% is chelated to ATP. Only 2% of total cell magnesium is in the biological active ionized form. In mitochondria about 0.9% magnesium is free (total: 32 nmoles/mg protein). The remainder is bound to membranes, proteins, ATP,ADP, Pi, citrate ect. Again ATPMg complex dominates with 53%. The concentration of ionized magnesium in cytosol and mitochondria is about the same.

An outstanding property of Mg++ is its tendency to form chelates. The physicochemical bases for this behavior is the very small ionic radius.

Quite a large number of enzymes are reported to be affected by this cation in one or the other way. It may act as cofactor, activator and/or inhibitor or the real substrate may be a Mg complex and it influences enzyme equilibria. In addition, variation of Mg++ concentration influences the free energy of ATP hydrolysis.

Total Mg++ content and free cellular Mg++ concentration in cells is controlled by hormones, ligand gated ion channels and exchange carriers. □-Adrenergic- or ß-adrenergic receptor agonists stimulate Mg++ efflux. Insulin antagonizes ß-adrenergic receptor stimulated Mg++ efflux. prostaglandin-E2 stimulate Mg++ influx in kidney tubule cells like insulin in platelets and lymphocytes. On the other hand secretion of insulin, secretin, parathyroid hormone and catecholamines is modulated by Mg++.

Activation of the NMDA receptor of neuronal cells or of the muscarinic receptor increases cytosolic Mg++. Arg-vasopressin, endothelin-1 or depletion of inositol-1,4,5-trisphosphate sensitive Ca++ stores, resulted in elevated levels of ionized Mg++ in muscle cells.

Efflux is catalyzed by a sodium/Mg++ exchanger in most cells and rat liver cells in addition contain a Ca++ /Mg++ exchanger.

In isolated mitochondria Mg++ concentration is modulated by the respiratory state, the membrane potential and the extramitochondrial Mg++ and phosphate.

Mg++ has yet not been considered as a regulator of gene expression. Recently a signal pathway was described for the regulation of the prodynorphin gene by Ca++. In this pathway Ca++ binds to a repressor called DREAM. Sequence analysis showed that this protein may contain a Mg++ binding site and it was speculated that Mg++ could also regulate this pathway. There are also some other findings for a possible effect of Mg++ on gene expression.

Mg++may also play a role in apoptosis. Triggering apoptosis by stimulation of the cell death receptor Fas in primary B-cells led to an increase of cytosolic Mg++ and this increase in Mg++ is an early event in the signaling pathway. In addition

glycodeoxycholic acid induction of apoptosis in rat liver cells is mediated by an increase in cytosolic Mg++, and Bax induced opening of the permeability transition pore of mitochondria, an other event in the apoptotic signaling pathway, is Mg++ dependent.
However also protecting effects have been reported. The opening of the permeability transition pore induced by the ganglioside GD3 or Ca++ was prevented by Mg++.
Strong evidence for an antioxidant and antiinflammatory effect of Mg++ was found in Mg++ deficient animals. Mg++ deficiency led to myocardial necrosis, fibrosis vascular lesions and is regarded as an atherosclerosis risk factor; antioxidants or Mg++ protected.
This review shows that in the recent years we have gained new insights in the molecular and cellular action of Mg++ but only part of the effects can be explained on a biochemical molecular basis.

STRESS REACTIONS IN MAGNESIUM DEFICIENCY.

Mildred Seelig

Stress hormones (catecholamines and corticosteroids), that evoke responses allowing for increased survival in life-threatening situations, can increase the risk of cardiac damage, as severe as sudden cardiac death when magnesium (Mg) deficiency exists. The stress hormones mediate release and utilization of substrates for production of energy and for improved voluntary and cardiac muscle performance, and mobilize tissue minerals: both Mg and calcium (Ca). The resultant (transitory) increase of serum Mg protects against arrhythmias and intravascularcoagulation in the short-term. However, if the serum Mg reach levels that exceed the renal threshold, it is excreted. Additionally, free fatty acids - released through the lipolytic effect of catecholamines - inactivate Mg in serum and tissues. Both responses intensify Mg deficiency. The stress hormone elevation of serum Ca, once the kidneys have restored Mg to the low limit of the normal range after the stress-induced rise, can result in a high enough Ca/Mg ratio to increase risks of both intravascular coagulation and arrhythmia. A vicious cycle can ensue, as high Ca/Mg ratios stimulate additional catecholamine secretion by the adrenal medulla and by secretory granules at nerve endings and in the myocardium. Conversely, high Mg/Ca ratios suppress catecholamine release. Low Mg also increases output of mineralocorticoids, which in turn directly enhance urinary excretion of Mg and intensify cardiopathogenicity of both Mg deficiency and catecholamine excess. Furthermore, low arterial tissue Mg can lead to coronary arterial constriction - directly and through humoral vasopressors. Reduced myocardial Mg increases vulnerability to cardiac damage, that can result in chronic disease. Genetic differences in Mg homeostasis may be responsible for differences in susceptibility to pathologic reactions to stress. Mg deficiency and stress mutually enhance one another

HYPOTHESIS REGARDING POTENTIAL INJURY OF THE ENDOTHELIUM OF THE NORMAL HEART COMPLICATING PROLONGED SPACE MISSIONS.

William J. Rowe, M.D.
William J. Rowe M.D. Former assistant clinical Prof. of medicine Medical College Of Ohio At Toledo.

The Russian experimental animal studies have demonstrated, with prolonged space flights, cardiac muscle injuries with impaired microcirculation, and high cardiac concentrations of catecholamines. Elevations of the latter and significant losses of body magnesium, have been shown with manned orbital space flights. Both of these alterations could be aggravated by the necessity of unremitting endurance exercise with magnesium ion deficiency partly due to the removal of free magnesium ions from the circulation by chelation with catecholamine-induced free fatty acids. There is the potential for 4 vicious cycles: 1). The inverse relationship between high catecholamines and low magnesium ions. 2). Coronary vasospasm induced by both of the latter with the potential for injury to the endothelium and reduction in endothelium-derived relaxing factors (nitric oxide). 3). Reduction in myocardial oxygen supply secondary to coronary vasospasm and local and systemic thrombogensis and with increased oxygen demand with the potential for severe ischemia conducive to further catecholamine release. 4). Magnesium ion deficiency enhancing angiotensin 2 action, resulting in increased aldosterone and in turn increased magnesium excretion. Both magnesium deficiency and high catecholamines may injure the heart through increased free radical formation, which in turn, may aggravate radiation-induced injuries by similar mechanisms. Finally the demonstration of diminished plasma cGMP (during weightlessness), which could be a result of endothelial injuries, supports this hypothesis.

THE ROLE OF SOME AMINO ACIDS IN POST-OPERATIVE FATIGUE AND IN CHRONIC FATIGUE SYNDROME

L. M. Castell1, J. Phoenix2, T. Yamamoto3, J. McGuire1 and E.A. Newsholme.1
1Cellular Nutrition Research Group, Univ. Dept of Biochemistry, Oxford OX1 3QU, U.K.; 2Univ. Dept of Medicine, P.O. Box 147, Liverpool L69 3BX, U.K; 3Health Sci. Lab., Tezukayama Univ., Nara, Japan.

The neurotransmitter 5-hydroxytryptamine (5-HT) is involved in fatigue and sleep. Its precursor, tryptophan, binds to albumin in the blood. Increased mobilization of plasma free fatty acids (FFA), which also bind to albumin, leads to more free tryptophan (FT) and thus to an increased rate of brain 5-HT synthesis, which may cause central fatigue. The branched chain amino acids (BCAA) compete with tryptophan for entry into the brain across the blood-brain barrier, thus an elevated plasma free tryptophan concentration results in an increased plasma concentration ratio of these amino acids (p[FT:BCAA]). Central fatigue is implicated in chronic fatigue syndrome (CFS) and post-operative fatigue.

Plasma albumin, free tryptophan, total tryptophan and BCAA were measured before and after major surgery; and in CFS patients before, during and after maximal exercise on a bicycle ergometer compared with sedentary controls. Ethical permission was obtained for all studies.

During post-operative recovery in both elderly and coronary artery bypass graft patients (CABG), plasma FT concentrations were significantly increased compared with baseline levels; the p[FT:BCAA] was also increased (Yamamoto et al., 1997). Plasma albumin concentrations were significantly decreased after surgery in both elderly and CABG patients. More recently both fatigue (as measured by the Profile of Mood States questionnaire)and plasma amino acid concentrations have been measured in patients after major surgery. An increase in post-operative fatigue has shown a trend towards a correlation with increased plasma free tryptophan.

In CFS patients, plasma free tryptophan was higher pre-exercise than in controls ($p<0.05$) but did not change during or after exercise. Plasma free tryptophan increased in the controls at maximal exercise ($p<0.02$), peaking at 5 min post-exercise ($p<0.001$), returning to baseline at 60 min. The baseline p[FT:BCAA] appeared 31% higher ($p<0.1$) in the CFS patients than in the controls and remained at similar levels during and after exercise. The apparent failure of these patients to change the p[FT/BCAA] during exercise may indicate increased sensitivity of brain 5-HT receptors as demonstrated in other studies (Cleare et al., 1995).

Provision of BCAA has improved mental performance in endurance athletes (Blomstrand et al., 1997). BCAA supplementation might help to counteract the effects of

an increase in plasma free tryptophan, and thus improve the symptoms associated with post-operative or chronic fatigue.

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COLD EXPOSURE AND SLEEP DEPRIVATION, CATECHOLAMINE-MAGNESIUM INTERACTION

Porta, S. Heidinger, D., Frise, E., Lang, T.
Institute for Applied Stress Research, Bad Radkersburg, Hauptplatz 2-4, AUSTRIA,
Endocrinological Research Unit at the Institute of General and Experimental Pathology, University of Graz, AUSTRIA
Psychological Service of the Austrian Army.

Aim of the study:

Increase in free plasma CA due to standard ergometry superimposed to an unknown stress is much fiercer than the reaction to the same ergometry before the unknown stress. This difference depends upon duration and severity of the unknown stress (Porta et al. 93).

The behavior of conjugated CA with their much longer half-life in this context may throw some light on both the scarcely investigated dynamics and their eventual diagnostic value.

Material and methods:

Internal standardization and exhaustive winter training.

Canulation and workload: 21 healthy officer trainees (age between 22 - 26) were fitted with a cannula into the antecubital vein at 8 am. 20 minutes later the first blood sample was drawn. Immediately after that they were subjected to bicycle ergometry, beginning with 50 Watts, adding 50 Watts more every two minutes until at last they had managed 300 Watts for the last two minutes. Six minutes after commencement of the work a second blood sample was drawn. The third sample was drawn immediately after the end of the ergometric bout. Blood samples and parameter determination: Out of a sample size of 20 ml blood per sampling the following parameters have been determined:

Hormones: free and conjugated dopamine, norepinephrine and epinephrine (HPLC, System Beckman Gold, electrochemical detector, BAS LC-4B)

i. a. BE and pO2 (AVL Omni)

Two months after this standardized ergometer check the group of probands has been subdivided into two equal groups. One of them was treated with 730 mg Magnesium (Magnosolv ASTA Medica Vienna) per day, the second one with placebo for ten days in a double blind study. The treatment was carried out during ten days of exhaustive military winter training in the Austrian Alps 1300m above sea level. The winter training was characterized by sleeplessness and physically demanding tasks along with constant cold exposure. On the evening of the 10th day the trainees have been given opportunity for a good 12 hours sleep in regular beds in normally heated rooms. At the following

morning the very same test and blood sampling procedures as described above were carried out.

Results:

Free and conjugated catecholamnies:

Ergometry increased free NE after fatigue in both pl- and Mg-treated groups to nearly twice the level of ergometry in barracks.

Rise in free epinephrine due to ergometry did not change in Pl-treated probands after fatigue compared to results in barracks, but did increase 2-folt in the Mg-treated group.

No difference between all groups in free dopamine behavior.

Conjugated epinephrine increased slightly in the barracks

Conjugated dopamine and NE generally increased considerably after fatigue, even more so in the Mg-treated group.

Rough schema of CA-increase:

Tab. 1. X-fold rise in free CA due to ergometry (approx.)

	barracks	Alpine	training
		Pl	Mg
free Dopamine	3x	5x	5x
free NE	2x	2x	4x
free Epinephrine	2x	2x	2x

No increase in conjugated CA due to ergometry after fatigue but increase in basal levels. Ergometry in barracks without previous fatigue did not increase conjugated dopamine and NE levels but slightly but significantly increased conjugated epinephrine.

Tab. 2.Increase in basal levels of conjugated CA compared to barrack basal level.

	barracks	Alpine	training
		Pl	Mg
conj. Dopamine	1	7x	8.5x
conj. NE	1	2.5x	3x
conj. Epinephrine	1	1	1

Discussion and Conclusion:

The additive effect upon increase of free NE and epinephrine of fatigue and ergometry is evident, still even after 12 hours rest.

Increase in free epinephrine after post-fatigue ergometry is significantly higher in the Mg-treated group than in placebos.

Basal levels of conjugated dopamine and NE after fatigue increase very considerably compared with those in barracks, and are significantly highest in the Mg-treated group. However there is no immediate reaction due to ergometry after fatigue.

Note: No significant increase in conjugated CA could be seen when measured immediately after a 3 days fatigue (Porta et al. 1992). Probably post-stress increase of conjugated CA does take its time, which could be used as a characteristic of stress in the immediate past (transition from stable to unstable angina pectoris, more sensitive than enzymes myocardial infarction?).

INTERNATIONAL CONGRESS FOR THE ASSESSMENT OF STRESS INTENSITY AND STRESS COMPATIBILITY IN LARGE GROUPS

Press information

NOV. 25TH – 27TH, BAD RADKERSBURG, AUSTRIA

Bad Radkersburg, Nov. 11th,1999

WAS HABEN THEMEN WIE:

Die Rolle von Magnesium bei interplanetaren Raumflügen

Stressmessung bei Wein- und Rockfesten

Voroperative Prognose von Risikogruppen für nachoperative Zwischenfälle

Stressbedingte Stoffwechselstörungen bei Sexualattentäter

Effekte von Stresshormonen bei Magersüchtigen

Proportionale Übereinstimmung von Blutveränderungen mit Punktezahlen bei Psychotests,

Objektive Beurteilung von Kurerfolgen

MITEINANDER ZU TUN?

Darüber unterhalten sich Wissenschaftler aus Deutschland, England, Österreich, Polen, Schweden und den USA am

CONGRESS FOR THE ASSESSMENT OF STRESS INTENSITY AND STRESS COMPATIBILITY IN LARGE GROUPS

den das Institut für Angewandte Stressforschung in Bad Radkersburg vom 25. bis 27. November durchführt.

Hauptsponsor ist die

US Airforce und das European Office for Aoerospace Research and Development, weil regelmäßig Studenten der US Airforce Academy in Bad Radkersburg die Stressbeurteilung größerer Gruppen mit einer Forschungsmethode, die hier entwickelt wurde, erlernen.

Die Funktionsweise des neuesten dazu notwendigen Gerätes österreichischer Produktion (Fa. AVL, Graz) wird am Kongress praktisch demonstriert.

Wir sind besonders stolz, daß dem kleinen Bad Radkersburg infolge des lokalen know-hows der Vorzug vor weit bekannteren Kongressorten gegeben wurde

Dr. S. Porta

Univ. Prof. Dr. Sepp Porta, A- 8490 Bad Radkersburg, Hauptplatz 2-4

Tel.:0043 34 76 31 46, Fax..0043 34 76 31 46, Email: stresscenter@netway.at

Press reaction

Auch US-Airforce baut in der Steiermark Stress ab

Ami-Luftwaffe ist Hauptsponsor von Kongress in Bad Radkersburg.

■ VON BERND CHIBICI

In Bad Radkersburg geht ab 25. November ein höchst ungewöhnlicher Kongress über die Bühne: Mehr noch als das Thema – Stress – sorgt der Hauptsponsor für Aufsehen: die US-Airforce.

Mit nur 30 Teilnehmern relativ klein, dafür aber fein wird das Ereignis in der südsteirischen Thermenstadt sein, die in Fachkreisen in Sachen Stressforschung einen exzellenten Namen hat. Der ist eng verbunden mit dem Wissenschafter Sepp Porta, der in Bad Radkersburg das Institut für angewandte Stressforschung leitet. Warum gerade dort? Mit „Longlife" sprudelt auch viel Magnesium aus dem Boden und das spielt eine Schlüsselrolle, wenn es um Stress geht.

Stressforscher Porta hat mit seinen Entdeckungen in den letzten Jahren die Militärs neugierig gemacht. Speziell die Luftwaffe der Supermacht USA sieht darin eine Chance, Einfluss auf das Verhalten der Kampfpiloten in Extremsituationen zu nehmen. Zwischen dem steirischen Wissenschafter und der US-Airforce hat sich ein enger Kontakt entwickelt, jetzt sind die Amis sogar der Hauptsponsor der bevorstehenden Tagung. Die hat noch eine weitere bemerkenswerte steirische Facette: Mit bei AVL-List gebauten Geräten für die Intensivmedizin hat Porta erstmals Möglichkeiten zur relativ einfachen und kostengünstigen Stress-Untersuchung größerer Gruppen gefunden. Darum geht's in erster Linie bei der Tagung.

Portas Anti-Stress-Regeln sind aber nicht nur für Kampfpiloten, sondern auch für gewöhnlich Sterbliche von großer Bedeutung:

■ „Muskelarbeit" ist für ihn die beste Methode, mit Stress fertig zu werden. So wird Stress-Energie in richtige Bahnen geleitet.

■ Ohne Magnesium geht im Kampf gegen den Stress fast gar nichts mehr. Das Problem: Viele leiden heute unter Magnesiummangel, aber die Körperreaktionen gegen den Stress brauchen es unbedingt.

■ Nach neuesten Entdeckungen hilft Glutamin besonders gut, mit Stress fertig zu werden. Die Steirer sind gesegnet mit einer reichen Quelle dieser Aminosäure – dem G'selchten. Glutamin-Nachschub gibt es auch in anderem – speziell rohem – Fleisch.

Anecdotal Information from Published Apollo Mission Reports

Head

— The Commander reported that he felt less zero-gravity effect, such as fullness of the head, than he had experienced on his previous flight. All three crewmen commented that the lack of a gravitational pull caused a puffiness underneath their eyes and this caused them to squint somewhat, but none felt any ill effects associated with this puffiness.

(Apollo 11)

— Aspirin tablets were also taken by the crewmen, but the number of tablets per individual was not recorded. The Lunar Module Pilot recalled that he had taken two aspirin tablets almost every night to aid his sleep.

(Apollo 11)

— All crewmen reported the sensation of fullness in the head, a condition which remained for 1 or 2 days after lift-off. Their eyes were bloodshot for the first 24 hours of flight and their faces appeared slightly rounded or swollen throughout the flight. They also reported that their shoulders tended to assume a squared-off (or raised) position, rather than being sloped in the usual relaxed position.

(Apollo 12)

— All crewmen took Actifed to relieve nasal congestion at various times throughout the flight. The Lunar Module Pilot reported taking Actifed prior to lunar module descent to relieve symptoms developed after earth lift-off.

(Apollo 12)

— The Commander and the Command Module Pilot both reported a feeling of fullness in the head lasting for several hours on the first day of the mission. The Lunar Module Pilot reported a similar feeling and also that he felt like he was "hanging upside down." The Commander reported that all crewmen had red eyes the first day of the mission.

(Apollo 13)

— Upon awakening on the second day of the mission, the Lunar Module Pilot complained of a severe headache. He took two aspirin, ate breakfast, and became immediately engaged in unrestrained physical activity. He then became nauseated, vomited once, and lay down for several hours. He then experienced no further nausea. The Lunar Module Pilot continued to take two aspirin every 6 hours to prevent recurrence of the headache. After the inflight incident, he took aspirin on only one occasion.

(Apollo 13)

— No medications, other than nose drops to relieve nasal stuffiness caused by spacecraft atmosphere, were used during the mission. On the third day of flight, the Commander and the Lunar Module Pilot used one drop in each nostril. Relief was prompt and lasted for approximately 12 hours.

(Apollo 14)

— Adaptation to the weightless state was readily accomplished. Shortly after orbital insertion, each crewman experienced the typical fullness-of-the-head sensation that has been reported by previous flight crews. No nausea, vomiting, vertigo, or disorientation occurred during the mission and the crew did not observe distortion of facial features, such as rounding of the face due to lack of gravity, as reported by some previous crewmen.

(Apollo 14)

— Shortly after orbital insertion, each crewman experienced the typical fullness-of-the-head sensation that has been reported by all previous flight crews. The Commander adapted rapidly to weightlessness and noted that on this flight, in contrast to his Apollo 9 experience, he felt completely at ease in the weightless state and was able to move his head rapidly without discomfort.

(Apollo 15)

— Adaptation to zero-g and subsequent readaptation to one-g were immediate and very natural. The zero-g environment can best be described as exhilarating. The one lingering nuisance of the zero-g environment is that the sinuses never stay clear for very long.

(Apollo 16)

— Shortly after earth orbital insertion, two crewmen experienced the typical fullness-of-the-head sensation that has been reported by all previous flight crews. This sensation lasted for several hours. The Command Module Pilot did not experience this sensation. No redness of the face was observed by the crew and all three crewmen adapted rapidly to weightlessness and did not experience any giddiness, nausea, vomiting, or disorientation.

(Apollo 16)

— Two of the three crewmen experienced the typical fullness-of-the-head sensation, one immediately after earth orbital insertion and the other after a 6-hour exposure to weightlessness.

(Apollo 17)

Stomach

— Based on the crew's postflight comments, the adaptation to weightlessness required approximately 1½ days. There were no instances of nausea, vomiting, or disorientation; however, all three crewmen did experience the need to limit their movements and perform the necessary movements slowly during the initial period of adaptation. In addition, all three crewmen had varying degrees of "stomach awareness" and a decreased appetite for the first 1½ days of flight. Once adapted, the crewmen were able to perform all types of movements without restrictions. No readaptation to weightlessness was required after residing for 75 hours on the moon at 1/6-g.

(Apollo 17)

Illusionary

— In donning and doffing the suits, they had no feeling of tumbling or the disorientation which had been described by the Apollo 9 crew.

(Apollo 11)

— The Command Module Pilot apparently experienced no difficulty in adapting to weightlessness, but the Lunar Module Pilot reported that his sensation of head-fullness lasted three days. In addition, the Lunar Module Pilot experienced slight giddiness which precluded rapid head or body movements. This sensation disappeared shortly after landing on the lunar surface and did not recur on returning to the zero-gravity environment.

(Apollo 15)

— One frequently asked question is, "Do you have any sensation of being upside down?" There were several times during the mission when the command module would appear to be in a stable II attitude (apex down). These instances seemed to follow periods in the lunar module and in the tunnel area with the head in the minus-X direction. There seemed to be a natural preference for the orientations used in training even though they were not the most efficient. On the other hand, the spacecraft orientation with respect to external objects was never annoying.

(Apollo 16)

Sleep

— It is interesting to note that the crewmen's subjective estimates of amount of sleep were less than those based upon telemetered biomedical data. By either count, the crewmen slept well in the command module. The simultaneous sleep periods during the translunar coast were carefully monitored and the crew arrived on the lunar surface well rested. Therefore, it was not necessary to wait until after the first planned 4-hour sleep period before conducting the extravehicular activity. The crewmen slept very little in the lunar module following the lunar surface activity. However, the crewmen slept well during all three transearth sleep periods.

(Apollo 11)

— Sleep periods during translunar coast began approximately 7 to 9 hours after the crew's normal bedtime of 11 p.m. The crew reported that they had no particular trouble in adapting to the shifted sleep periods. However, the first flight day was extremely long and the crew was thoroughly fatigued by the time the first sleep period began 17 hours after lift-off. The crewmen slept well in the command module during the translunar and transearth coast phases and the Lunar Module Pilot took at least two unscheduled naps during transearth coast. However, they reported their scheduled sleep periods were longer than necessary, since they would invariably awaken about 1 hour ahead of time and would usually remain in their sleep stations until time for radio contact.

— The lunar module crew slept only about 3 hours on the lunar surface prior to the second extravehicular activity period. In the next sleep period following rendezvous and docking, all three crewmen in the command module slept only 3 or 4 hours, which was less than desirable.

(Apollo 12)

— The crew reported sleeping well the first 2 days of the mission. They all slept about 5½ hours during the first sleep period. During the second period, the Commander, Command Module Pilot, and Lunar Module Pilot slept 5, 6, and 9 hours, respectively.

(Apollo 13)

— The shift of the crew's normal terrestrial sleep cycle during the first four days of flight was the largest experienced so far in the Apollo series. The displacement ranged from 7 hours on the first mission day to 11½ hours on the fourth. The crew reported some difficulty sleeping in the zero-g environment, particularly during the first two sleep periods. They attributed the problem principally to a lack of kinesthetic sensations and to muscle soreness in the legs and lower back. Throughout the mission, sleep was intermittent, i.e., never more than 2 to 3 hours of deep and continuous sleep.

(Apollo 14)

— Following transearth injection, the crew slept better than they had previously. The lunar module crewmen required one additional sleep period to make up the sleep deficit that was incurred while on the lunar surface.

(Apollo 14)

— In contrast to the Commander's Apollo 10 experience, he slept well during all the scheduled sleep periods. Typically, the Commander's sleep was uninterrupted for 4 to 5 hours after which he would awaken, get a drink of water, and return to sleep for the rest of the night. The Lunar Module Pilot slept well

during all sleep periods except the first. However, the Command Module Pilot reported that he slept uninterrupted only two nights of the mission and, characteristically, would awaken about once every hour. He also stated that he never felt physically tired nor had a desire for sleep.

(Apollo 16)

— The Lunar Module Pilot used three 100-milligram Seconal capsules for sleep induction during the mission. One capsule was taken on the night prior to lunar descent and the other two capsules were used for the first and second lunar surface sleep periods, respectively. In the postflight medical debriefing, the Lunar Module Pilot reported that the Seconal was effective in producing a rapid onset of good sleep.

(Apollo 16)

— The Command Module Pilot felt that the flight of Apollo 16 was less fatiguing than the preflight preparations. In fact, he was considerably more rested on the final day of the mission than on launch day. He slept soundly and continuously on only two nights, the first solo day in lunar orbit and the night following transearth injection, but he never felt sufficiently tired to be able to go to sleep. The sleep obtained during the other nights could, at best, be classified as intermittent. Terrestrially, the Command Module Pilot averages about 6½ hours of sleep per night and is generally physically tired when going to bed. Seconal was not used by the Command Module Pilot. Qualitatively, the Command Module Pilot feels that zero-g had no effect on his ability to sleep unless the attendant lack of muscular fatigue is involved. The Command Module Pilot could recall no dreams.

(Apollo 16)

— As on previous missions, displacement of the terrestrial sleep cycle contributed to some loss of sleep. In addition, changes to the flight plan occasionally impacted previously planned crew sleep periods. In general, however, an adequate amount of good sleep was obtained by all crewmembers. The estimates of sleep duration made by ground personnel were in general agreement with the crew's subjective evaluations.

(Apollo 17)

Appetite

— During the first 2 days of the flight, the Command Module Pilot reported that half a meal was more than enough to satisfy his hunger, but his appetite subsequently returned.

(Apollo 11)

Muscular

— As in previous Apollo missions, the inflight exerciser was used primarily for crew relaxation. The crew used the exerciser several times each day for periods ranging from 15 to 30 minutes during the translunar coast.

(Apollo 12)

— During the first two days of flight, the crew reported discomfort and soreness of the lower back muscles as has been noted on previous missions. The discomfort was sufficient in magnitude to interfere with sleep during the first day of the mission, and was attributed to changes in posture during weightlessness. Inflight exercise provided relief.

(Apollo 14)

— None of the crewmen experienced nausea, vomiting, or disorientation during any phase of the mission. An observation made by the crew was that their facial features were distorted because of the lack of gravity. The crew also reported the discomfort and soreness of the lower back muscles associated with postural changes during weightlessness.

(Apollo 15)

— Previous crews have commented on pains in the lower back. The Apollo 16 Command Module Pilot felt none of these.

(Apollo 16)

Miscellaneous

— The planned exercise program included isometric and isotonic exercises and the use of an exerciser. As in previous Apollo missions, a calibrated exercise program was not planned. The inflight exerciser was used primarily for crew relaxation. During transearth coast, the Lunar Module Pilot exercised vigorously for two 10-minute periods. His heart rate reached 170 and 177 beats/min, and the partial pressure of carbon dioxide increased approximately 0.6 mm Hg during these periods. The heart rates and the carbon dioxide readings rapidly returned to normal levels when exercise ceased.

(Apollo 11)

Readaptation

— The Lunar Module Pilot had a small amount of clear fluid with air bubbles in the middle ear cavity, but this symptom disappeared after 24 hours of decongestant therapy.

(Apollo 12)

— Both the Commander and the Command Module Pilot had a small amount of clear, bubbly fluid in the left middle ear cavity and slight reddening of the eardrums. These findings disappeared in 24 hours without treatment. The Lunar Module Pilot had moderate eyelid irritation in addition to slight redness of the eardrums.

(Apollo 14)

— The Commander had some sinus congestion which responded promptly to medication, and also a slight reddening and retraction of the right eardrum.

(Apollo 16)

— All crewmen were within normal limits during preflight tests. However, three days after recovery, two of the crewmen

exhibited a significant decrement when deprived of all visual sensory cues. Performance was similar to the preflight baseline when these crewmen were retested one week after landing.
(Apollo 16)

SUMMARY OF THE LITERATURE

Several summaries of physiological changes have been published in the literature. Some of these are listed here.

Overview

Table 1: Physiological Changes Associated with Short-Term and Long-Term Space Flight. *Space Physiology and Medicine*, pp. 128-134.

Table 4: Reactions of Man and Animals to Effects of Weightlessness. *Foundotions of Space Biology and Medicine*, Volume II, Book 1., pp. 316-318.

Table 5: Overivew of Current Hypothesis Concerning Processes Involved in Man's Adaptation to Zero Gravity. *Foundations of Space Biology ond Medicine*, Volume II, Book 1., p. 321.

Figure 5: Effects of the Influence of Weightlessness on Man. *Foundotions of Spoce Biology ond Medicine*, Volume II, Book 1., p. 319.

Figure 6: Proposed Process of Adaptaton to Weightlessness. [Pre-SKYLAB hypothesis] *Foundations of Space Biology and Medicine*, Volume II, Book 1., p. 322

Cardiovascular

Figure 5: Suggested Cardiovascular Response to Weightlessness. *Spoce Physiology ond Medicine*, p. 168.

Table 40-VI: Skylab Cardiovascular Summary. *Biomedicol Results from Skylob*, p. 412.

Table 1: Percent Change After Designated Condition from Preflight Supine Resting Reference Values. *Space Physiology ond Medicine*, p. 179.

Orthostatic Toleronce

A decrease in orthostatic stability was noted following the first manned spaceflights and has been confirmed repeatedly. This orthostatic intolerance is believed to be a result of dehydration changes and total circulating blood volume.

Table 6: Apollo Group Mean Values for Preflight Summary and Postflight Orthostatic Evaluations. *Biomedicol Results from Apollo*, pp. 245, 246.

Cardiac Size

Standard chest x-rays, taken before and after spaceflight, show that the size of the heart decreases when man is exposed to weightlessness.

"Combining the data from 4 Mercury, 18 Gemini, 30 Apollo and 9 Skylab crewmen, postflight decrements in CT [cardio-thoracic] ratio averaged -.018." *Space Physiology and Medicine*, p. 176.

Table 10: Apollo Crewmen Cardiothoracic Ratios During Orthostatic Evaluations (Ratios Based on X-Radiographs). *Biomedicol Results of Apollo*, p. 253.

Muscle Mass

When the astronauts are exposed to zero-g for moderate periods their body begins an adaptation process. Part of this process is a loss of muscle mass which possibly includes the cardiac muscle. *Foundations of Space Biology ond Medicine*, p. 321.

"In general, these analyses [biosterometric measurements] of body form revealed striking losses of volume in the abdomen, buttocks, and calves, and less striking losses in the thighs. The authors concluded that the losses observed in the abdomen and the buttocks are probably due mainly to loss of fat, and those observed in the legs, particularly the calves, are due partly to fluid losses and partly to the reduction in muscle mass associated with spaceflight." *Space Physiology ond Medicine*, p. 193.

". . .muscle tissue is most affected by weightlessness early in flight. . ." *Spoce Physiology ond Medicine*, p. 190.

"Investigation of skeletal-muscle function in both leg and arm flexor muscles, using electromyographic analyses, showed that muscle dysfunction characteristics found after 59 days of exposure to weightlessness in the Skylab 3 mission were also evident after only nine days of exposure (LaFevers et al., 1977)." *Space Physiology ond Medicine*, p. 15.

Limb Girth.

As a result of exposure to a weightless environment, astronauts experience a decrease in the circumference of the calfs. Muscle tone and strength also diminish during long exposures to zero-gravity. *Foundotions of Space Biology ond Medicine*, p. 318.

"Astronauts have typically demonstrated inflight decrements in calf girth of up to 30%." *Space Physiology ond Medicine*, p. 166.

Potential myocardial injuries to normal heart with prolonged space missions: The hypothetical key role of magnesium

W. J. Rowe

Zusammenfassung

Russische tierexperimentelle Studien haben bei längeren Weltraumflügen Schädigungen des Herzmuskels aufgezeigt, die mit gestörter Mikrozirkulation und hohen myokardialen Katecholamin-Konzentrationen einhergingen. Anstieg der Katecholamine und signifikante Magnesiumverluste sind auch bei bemannten Weltraumflügen gezeigt worden. Beide Veränderungen könnten verstärkt werden durch die unablässige Belastung mit einem Defizit an Magnesium-Ionen, das durch Bindung von Magnesium-Ionen an Freie Fettsäuren entsteht, wobei letztere durch die Katecholamine freigesetzt werden. Ein Circulus vitiosus kann potentiell aus vier Mechanismen resultieren: 1. über die inverse Beziehung zwischen hohen Katecholaminspiegeln und niedrigen Konzentrationen an Magnesium-Ionen, 2. über hierdurch induzierte Koronarspasmen, welche das Endothel schädigen und so die Produktion von EDRF (endothelium-derived relaxing factor), d.h. von Stickoxid, vermindern, 3. über eine Verschlechterung der myokardialen Sauerstoffversorgung als Folge der Koronarspasmen und lokaler Thrombenbildung bei erhöhtem Sauerstoffbedarf und entsprechender Ischämie-induzierter weiterer Katecholamin-Liberation sowie 4. über eine verstärkte Angiotensin II-Wirkung aufgrund des Defizits an Magnesium-Ionen, wodurch Aldosteron freigesetzt wird, das wiederum die Magnesiumausscheidung erhöht. Magnesiummangel als auch hohe Katecholaminspiegel können das Herz durch erhöhte Bildung freier Radikale schädigen, die wieder die durch Strahlung bedingte Anhäufung ähnlicher Faktoren verstärken können. Aufgrund der durch Schwerelosigkeit bedingten, denkbaren Malabsorption ist es naheliegend zu spekulieren, dass eines Tages den Astronauten Magnesium über ein subkutanes Mikrochip-gesteuertes System zugeführt wird.

Summary

The Russian experimental animal studies have demonstrated, with prolonged space flights, cardiac muscsle injuries with impaired microcirculation, and high cardiac concentrations of catecholamines. Elevation of the latter and significant losses of body magnesium, have been shown with manned orbital space flights. Both of these alterations could be aggravated by the necessity of unremitting endurance exercise with magnesium ion deficiency partly due to the removal of free magnesium ions from the circulation by chelation with catecholamine-induced free fatty acids. There is the potential for 4 vicious cycles; 1. The inverse relationship between high catecholamines and low magnesium ions. 2. Coronary vasospasm induced by both the latter with the potential for injury to the endothelium and reduction in endothelium-derived relaxing factors (nitric oxide). 3. Reduction in myocardial oxygen supply secondary to coronary vasospasm and local and systemic thrombogenesis and with increased oxygen demand with the potential for severe ischemia conducive to further catecholamine release. 4. Magnesium ion deficiency enhancing angiotensin 2 action, resulting in increased aldosterone and in turn increased magnesium excretion. Both magnesium deficiency and high catecholamines may injure the heart through increased free radical formation, which in turn may aggravate radiation-induced injury by similar mechanisms. Because of space-related potential malabsorption, it is tempting to speculate, that some day astronauts might receive magnesium by a subcutaneous microchip drug delivery device.

Introduction

About a decade ago, I developed an hypothesis, that extraordinary unremitting endurance exercise could injure permanently the normal heart, based upon my study of *Sy Mah*, who at that time was the holder of the Guinness Book of Records for having completed the most marathons [1, 2]. Several years later, I postulated that the normal heart could be injured as well, when subjected to particularly long space missions, by somewhat similar but more complex mechanisms [3, 4]. The space-related mechanisms stem from hypokinesia and microgravity, resulting in invariable dehydration as a result of both [5].

In the mid-ninties, at a Workshop on Microgravity Research, it was postulated that on space missions, the endothelium was at risk of becoming injured secondary to both mechanical and biomedical insults [6]. The presence of insulin resistance by astronauts during space flight [7], which could be secondary to a reduction of microvascular vasodilator capacity [8], and the significant reduction in cyclic-GMP (a second messenger of nitric oxide) [9] support the hypothesis suggested at this microgravity workshop, with the postulated mechanisms recently published [4].

Experimental animals in space

Studies by the Russians, of experimental animals in space, demonstrated pronounced impaired microcirculation and serious myocardial pathology, even on space flights of only a few weeks. Edema of the endothelium was demonstrated, with altered endothelial permeability, and some of the coronary vessels were completely occluded. There was also noted atrophy of the cardiac muscle. Other studies

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suggested the possibility that some of these changes were stress-related, since there was significant increase in the concentration of norepinephrine in cardiac tissue. Finally, in addition to decreased activity of enzymes with injury of the mitochondria, there was evidence of impairment in the repair mechanism [5]. These animal studies suggest that even relatively brief space missions, may predispose to a myocardial infarction in the absence of coronary artery disease prior to the space flight.

Mechanisms for endothelial injury

Too much or too little exercise may damage the endothelium through similar mechanisms [4]. Therefore, the intensity, duration, and frequency of exercise would have to be individualized on longer missions, rather than utilizing a rigid exercise schedule for all crew members.

High shear stress and turbulence, precipitated by catecholamine-induced coronary vasospasm may injure the endothelium and in turn lead to further vasospasm by a vicious cycle. High catecholamines, with release of high levels of free fatty acids, which bind magnesium ions, may persist by ongoing vicious cycles as well. A third vicious cycle can be precipitated by elevations of catecholamines related to ischemia. These mechanisms can injure the normal heart from extraordinary unremitting endurance exercise [2, 3].

On space flights, because of skeletal muscle and bone loss, thereby depleting the magnesium reservoir, the potential for a magnesium deficit [5, 10-13] is far greater than the potential deficit of magnesium from unremitting exercise alone.

There are in addition, invariable angiotensin elevations complicating hypokinesia [13, 14], microgravity [5] and specifically secondary to impairment in the thirst mechanism [14, 15]. *Zorbas* has shown in experimental animals [14] and humans [16] subjected to hypokinesia, that even relatively brief periods of hypokinesia (as little as 7 days of strict bedrest) with partial loss of the water reservoir in skeletal muscle primarily [15], can cause pronounced dehydration, stemming from a marked increase in the rate of fluid excretion [16].

With the additional insult of microgravity, resulting in a shift of fluid to the upper part of the body, the volume regulating Henry-Gauer reflex, causes excess renal loss of extracellular fluids in short-term flights, and during long space missions, greater loss of intracellular fluids [5].

A water deficit [17] is clearly a two-edged sword with the potential of injuring ultimately the endothelium [4, 10], because not only is there a compensatory potentially damaging elevation of the renin-angiotensin system [5], but a devastating effect upon the endothelilum from loss of the protective effect of water counteracting increased free radicals (superoxide anions) [18]; these superoxide anions inactivate nitric oxide [19].

It is conceivable that on the Apollo-15 mission in 1971, a malfunction of the in-suit water device of *James Irwin*, resulting in no access to water for up to 7 hours on 3 excursions on the lunar surface, contributed to *Irwin's* myocardial infarction 21 months after that mission, by injuring the endothelium [4, 10].

In addition to catecholamine elevations produced by high angiotensin levels and exercise as well as magnesium deficiencies [4], sleep deprivation can contribute to these catecholamine elevations. *Monk* et al. [20] have shown that in a study of astronauts on a space mission, the mean number of hours of sleep was reduced to 6.

Catecholamines [17] can undergo autoxidation with the electrons produced, captured by molecular oxygen, producing superoxide anions and other activated oxygen species [21]. Magnesium ion deficiency, aggravated by excessive catecholamines with in turn a vicious cycle, would contribute to this oxidative stress [4, 22].

Whereas nitric oxide [4, 10] is a vasodilator and is antithrombotic, as well as an antioxidant, angiotensin-II is a vasoconstrictor, prothrombotic and a pro-oxidant. An imbalance between angiotensin-II and nitric oxide may alter the adhesive properties of the endothelial lining and ultimately lead to atherogenesis [19].

Insulin resistance

In addition to the potential for endothelial injuries from microgravity and hypokinesia, resulting in 3 vicious cycles [4], there is the potential for a fourth vicious cycle. Magnesium deficiency, by enhancing the activity of angiotensin-II, and thereby increasing aldosterone release, would in turn increase the renal loss of magnesium resulting in a vicious cycle [23, 24].

Since insulin resistance may be precipitated by a magnesium deficiency [23] and high sympathetic tone [25, 26], it is not surprising that insulin resistance has been demonstrated during space flights [7, 17]. Using C-peptide as a marker for insulin secretion (C-peptide is released by the processing of proinsulin into mature insulin [27] *Stein* et al. [7] demonstrated during a space flight as well as bedrest that C-peptide excretion increased with time, while energy intake remained constant, indicative of insulin resistance. A reduced capillary surface area, with impairment in microvascular endothelial function, may contribute to insulin resistance [8]. This may be because the diffusion distance from capillary to muscle cells, where glucose is taken up, would be increased [28].

Since insulin sensitivity relates to microvascular function, the presence of insulin resistance during space flights supports the hypothesis that space missions may predispose to endothelial dysfunction [29, 30], which may ultimately lead to coronary heart disease [10, 31].

This hypothesis is further supported by the finding of a significant reduction in plasma cyclic GMP (a second

messenger of nitric oxide) during a long-term space flight and after 5 days of simulated microgravity (6° head-down tilt) [9].

Radiation

Although the radiation exposure on orbital flights [5] and the Apollo missions [10], were not considered significant, the degree of radiation risk on a Mars mission is unknown, but is expected at times to be quite high [32]. Even with radiation shelters on board, the flights would have to be scheduled in such a way as to reduce exposure to high cosmic rays and solar flare activity [32]. The potential radiation risk to the coronary vessels [33], by impairment in endothelial function, with decreased nitric oxide production [34], would compound potential injuries induced by hypokinesia and microgravity.

Calcium overload

In addition to the previously described ischemic mechanisms which may lead to calcium overload [35] of the myocardium and the arterial wall, and potentially leading to a myocardial infarction, other conditions complicating space flights, can precipitate calcium overload with cell necrosis, i.e. catecholamine elevations [36], insulin resistance [37] and magnesium ion deficiency [38].

Still another contributing factor of possible significance in this regard, is the presence of elevated carbon dioxide levels, as noted in the Russian space station MIR (Euro MIR 94). Whereas the normal CO_2 conditions on Earth is .03%, during the Euro MIR 94 missions, readings of .5%-.7% CO_2 were obtained. Studies of chronically elevated CO_2 atmosphere by *Drummer* et al. [39] revealed reduced serum calcium levels, despite a reduction in fecal and urinary calcium losses. Since there was suppression of bone formation as well, these investigators suggested that there may be, with prolonged space missions, an intracellular shift of calcium, related to this high CO_2 environment.

A look into the future

If too much or too little exercise on space missions can injure the normal heart [1-4, 10, 11] and if no matter how much one exercises or how much water is ingested, the reservoir in muscle and bone of vital electrolytes such as potassium and magnesium and in addition water, remain depleted [11-14], what can be done to protect the myocardium? Certainly with the array of side effects complicating the usage of pharmaceuticals, it would be impractical to administer these to astronauts on space missions at least in the foreseeable future. Assuming that over the next few decades, methods will be developed to protect the space crews from high radiation, and potential risk from elevated CO_2 levels, what further measures appear imperative for a Mars mission?

Selection of crews

In addition to excluding astronaut candidates with obvious risk factors for cardiovascular disease, it appears prudent to avoid those candidates with the Ace DD genotype since this genotype may be conducive to angiotensin-II elevations particularly in the absence of other risk factors for coronary artery disease [3, 4].

In addition, it appears reasonable to avoid selecting astronauts who might experience deterioration of endothelial function with aging. After age 30 – unfortunately for all of us – the delicate endothelial cells are replaced by inadequate substitutes [4, 40]. Therefore, I believe, our best chance of avoiding endothelial injuries with the potential of irreversible vascular injury or death, is to ensure that the crew return from Mars before age 30 [40].

Finally, in selecting a crew for a Mars mission, it should be kept in mind, that being a male is an obvious risk factor for coronary disease; in the third and fourth decades the mortality rate from ischemic heart disease is 6 times greater than in females [41]. Therefore, I suggest, that for a Mars mission, our best chance of success is with an all female crew [4, 42]. It is noteworthy that on marginal magnesium intakes, young females retain magnesium better than young males. Estrogen's enhancement of magnesium utilization and uptake by soft tissues and bone, may explain the resistance of young women to heart disease [41]. Clearly this would be an advantage to astronauts with the potential for irreversible depletion of magnesium reservoirs [11, 13]. Even in the fifth decade, skeletal muscle magnesium is significantly higher in normotensive women, compared to normotensive men [43].

„Pharmacy on a Chip"

On a Mars mission, if magnesium stores are progressively depleted with in turn the impossibility of completely correcting potassium deficits [13, 44] what measures can be taken to resolve this potentially fatal problem? *Seelig* [44] has emphasized that in the presence of an aldosterone-induced chloride loss (as might occur from a magnesium deficit [23]) resulting in a metabolic alkalosis, and volume contraction, only with magnesium chloride can the potassium depletion be corrected.

But with the magnesium reservoir depleted, and in the presence of space-related potential malabsorption [45], what can be done to ensure adequate magnesium levels? A recently developed non-invasive method of measuring tissue magnesium levels, perhaps daily if necessary, coupled with recently patented control-release microchips might provide a solution.

Less than 1% of the total body magnesium is in the serum, and red blood cell levels do not always represent the true magnesium status of the body tissues. The availability of measuring the whole cell magnesium content in sublingual cells, might be utilized daily, to determine the proper dosage

of magnesium to be administered, for example on a Mars mission. Sublingual magnesium determinations have been shown to correlate closely with cardiac tissue levels [46, 47].

But if magnesium is not adequately absorbed under conditions of spaceflight [45] through the intestinal route and subcutaneous magnesium is not yet available, how can magnesium be delivered adequately to restore the vital reservoir? If a suitable subcutaneous magnesium product can be manufactured, there may be an innovative device to administer it to astronauts daily if needed. *Santini* et al. have just patented a microchip, which can be imbedded subcutaneously; this has the capability of providing the administration of over 1000 minidoses of a substance [48]. Perhaps other electrolytes can be administered on very long space missions by this method as well.

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Correspondence to:
William J. Rowe, M.D.,
Former Clinical Assistant,
Professor of Medicine,
Medical College of Ohio at Toledo,
12548 W. Bancroft, Swanton,
OH 43558, USA

Typical behavior of Mg, electrolyte, blood gas, and blood glucose in physically and psychically stressed individuals

S. Porta[1,2], W. Temmel[1,2], T. Gifford[1,3], J. Rand[1,3], D. Westmoreland[1,3], G. Porta[1]

Zusammenfassung

Bei 21 Militärakademikern wurden vor und nach einer 12 minütigen Fahrradergometerbelastung von maximal 250 Watt Blutgase (AVL compact 3), Mg, Na und Ca (AVL 988-4) und Blutzucker (Glukoseoxidase-Methode) gemessen. Die Ergebnisse wurden mit den gleichen Parametern verglichen, die von 13 Probanden knapp vor einem Bungee-Sprung gewonnen worden waren, nachdem die Versuchspersonen stundenlange Erwartungsangst ausgestanden hatten.

Die wichtigsten Ergebnisse: Mit der Ausnahme von 2 Teilnehmern konnten alle Bungee-Springer ihre signifikant niedrigeren Basenexzesse respiratorisch kompensieren, was in der Fahrradergometergruppe nicht der Fall war. Darüber hinaus zeigten die länger psychisch gestressten Bungee-Springer – im Gegensatz zur Ergometergruppe – deutlich und signifikant erhöhte Blutzucker und Na Werte (Risikofaktoren für koronare Herzkrankheiten (KHK)).

Lineare Interparameter-Korrelationsmuster innerhalb der Gruppen entstanden dort, wo Kompensationen nicht mehr möglich waren. In diesem Zusammenhang scheinen gerade Korrelationen zwischen Magnesium und pO_2 sowie pCO_2 in der Gruppe mit hoher Glukose und Na auf bereits limitierten Energieumsatz, vermutlich bedingt durch den länger dauernden psychischen Stress vor dem Sprung hinzudeuten.

Summary

Blood gases (AVL compact 3), Mg, Na, Ca (AVL 988-4) and blood glucose (glocoseoxidase method) was measured out of 21 officer trainees before and after a cycle-ergometric workload of up to 250 watts for 12 minutes. The data were compared with the same parameters taken from 13 subjects shortly before accomplishing a bungee jump, thus having been subjected to hours of anxious waiting.

Most important results: With the exception of 2 subjects, the bungee jumpers were able to respiratorily compensate their significantly lowered BE values without significant pH changes, which the ergometric group was unable to do. Furthermore, the psychologically stressed jumpers exhibited a marked and significant increase in blood glucose and Na, risk factors for ischemic heart disease. Those were absent in the ergometric group.

Linear interparameter correlation patterns within the groups showed, that linear correlations evolved preferably within those groups, which were unable to compensate. In this context, correlations with Mg and pO_2 and pCO_2 in the group with high glucose and Na seem to mark already limited metabolic turnover, probably related to pre-jumping anxiety stress of longer duration.

Introduction

Contrary to the situation at physical workload, psychological indueed increase in catecholamines is rarely coupled with increased energy turnover in muscle. On the other hand, psychical irritations – at least within the usual scope of our society – are generally more prolonged than physical loads.

To investigate both situations, it was tempting to compare a fatiguing 12 minutes cycle-ergometric workload with pre-bungee jumping anxiety during long hours, whereby our transportable measuring systems enabled us to perform on the spot determinations.

Of special interest for us was the behavior of ionized Mg in context with other blood gas or electrolyte values, because we knew from an earlier paper (*Porta* et al., same issue), that eventual correlation of circulating ionized Mg with some of the other parameters within so called "Interparameter Correlation pattern", (IPC), should be a reliable indicator for changing metabolic conditions, probably brought about by stress effects.

Materials and methods

21 male soldiers of the Austrian Army were subjected to a standardized ergometric program (Monark 834E and Ergo-Line, Ergo-Metrics 800S). The program was twelve minutes in duration, consisting of four, three-minute intervals of controlled power output of 100 watts, 150 watts, 200 watts and 250 watts, respectively. The intervals were completed in sequence and without resting between them. Before and after ergometry, three drops of capillary blood were drawn from the fingertip for determination of lactate (Boehringer-Mannheim) (mmol/L), pH, partial pressure of carbon dioxide (pCO_2) (mmHg), base excess (BE) (mmol/L), hydrogen carbonate (HCO_3) (mmol/L), partial pressure of oxygen (PO_2) (mmHg) and percent oxygen saturation (O_2sat) (AVL Compact 3) as well as ionized sodium (Na) (mmol/L), ionized magnesium (Mg) (mmol/L), and ionized calcium (Ca) (mmol/L) (AVL988-4) and Blood Glucose (Glucose-Oxidase Method) (mg/dL).

The group of soldiers both before ergometry (group Sb) and after ergometry (group Sa) was compared with a group of 13 civilian (group BJ) tested immediately prior to bungee jumping 82 and ½ meters from a railroad bridge. Three drops of capillary blood were

[1] Institute of Applied Stress Research Bad Radkersburg, Austria
[2] Institute of General and Experimental Pathology, University of Graz, Austria
[3] U.S. Air Force Academy Department of Biology

drawn from the fingertips immediately before the subjects completed their jump. The blood was tested for the same parameters as previously stated for the soldiers.

The data were recorded and analyzed (t-test and linear correlations) using Microsoft Excel. All participants gave their consent according to the Helsinki Charter, being fully aware of the nature and the purpose of the experiment.

Results

Average values were determined from blood samples, taken before and after ergometry in groups Sb and Sa respectively and before the jump in group BJ (see Tab. 1, 2). The average basal pH value in group BJ was statistically indistinguishable from the average basal value of group Sb. Ergometry decreased the pH value significantly as seen in group Sa ($p < 0,001$). Although the pH values of groups BJ and Sb were statistically indistinguishable, the BE in group BJ was significantly lower then in group Sb ($p < 0,001$), but significantly higher then group Sa ($p < 0,001$). Accordingly, pO_2 increased ($p < 0,001$), but pCO_2 and HCO_3 values in group BJ were significantly lower than in Group Sb ($p < 0,001$ and $p < 0,001$ respectively). However, average values for these three parameters were statistically indistinguishable between groups BJ and Sa. O_2sat values in group BJ were significantly higher than pre-ergometric values in group Sb ($p < 0,001$) as well as post ergometric values in group Sa ($p = 0,03126$). Concerning electrolytes, Na levels were higher in the BJ group compared to both the Sb group ($p = 0,00291$) and the Sb group ($p = 0,00451$). Ca exhibited a similar relationship ($p = 0,01023$ and $p = 0,03846$). Average Mg values in all groups were statistically indistinguishable. The group BJ showed the highest glucose values while the Sa group showed the lowest, significantly lower than the BJ group ($p = 0,00201$).

Although there was no difference in average ionized Mg values between the groups, linear correlations between the measured parameters within the three groups (IPCs, see *Porta* et al., same issue), show differing behavior (see Tab. 3, 4, 5). Notably, there was no significant correlation of BE with either pCO_2, pO_2, or pH in the Sb and BJ group, while all three correlated with BE in the Sa group. Moreover, significant positive linear correlations were seen only in the BJ group with pO_2 and pCO_2.

Discussion

In a former paper it could be shown that from a combination of electrolyte, blood gas, and glucose analysis along with a post stress provocation test it is possible to discern between different workloads causing stress in the immediate and not so immediate past. Similar methods can be applied to discern between a physical stress and a psychical stress. In this case a comparison between a diffficult 12 minute ergometric workout and a few hours of anxiety before a bungee jump. There existed some characteristics of the two groups that made the nature of their stresses clearly distinguishable. We saw, for example, that psychically stressed individuals exhibited the same pH values as a group of rested individuals, although their BE was considerably lower. The behavior of their pCO_2 and pO_2 values confirmed successful respiratory control. It must be noted that two of the psychically stressed individuals were already clearly

Tab. 1: Average Values for Group BJ, Group Sb and Group Sa — pCO_2 in mmHg, Na in mM/l, BE in mM/l, Mg in mM/l, HCO_3 in mM/l, Ca in mM/, pO_2 in mmHg, Glucose in mM/l, O_2sat in %

Average ±SEM	pH	pCO_2	BE	HCO_3	pO_2	O_2sat	Na	Mg	Ca	Glu
BJ	7,337	38,5	-4,9	20,1	60,0	87,6	146,5	0,49	1,32	96
	±0,011	±1,6	±0,6	±0,7	±2,3	±1,2	±0,6	±0,01	±0,02	±3
Sb	7,326	53,4	0,2	27,0	32,1	54,9	144,2	0,48	1,25	89
	±0,005	±0,9	±0,2	±0,3	±1,4	±3,0	±0,2	±0,01	±0,01	±3
Sa	7,208	40,9	-11,6	16,0	63,6	79,4	145,6	0,49	1,28	85
	±0,013	±1,8	±0,9	±0,8	±4,3	±3,4	±0,4	±0,01	±0,01	±2

Tab. 2: t-Values for Group Differences (Units like table 1)

t-Test	pH	pCO_2	BE	HCO_3	pO_2	O_2sat	Na	Mg	Ca	Glu
BJ vs. Sb		p<0,001	p<0,001	p<0,001	p<0,001	p<0,001	p<0,01		p<0,05	
BJ vs. Sa	p<0,001		p<0,001	p<0,001		p<0,05				p<0,01
Sb vs. Sa	p<0,001	p<0,001	p<0,001	p<0,001	p<0,001	p<0,001	p<0,01		p<0,05	

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Tab. 3: Interparameter Correlation Pattern (ICP) of Group BJ (Units like Tab. 1)

pH	*-0,6059	0,4001	-0,0007	-0,4271	-0,0462	-0,1319	-0,5256	0,3768	-0,4756
	pCO_2	0,4486	**0,7943	0,5628	0,3912	0,4275	*0,592	-0,1506	0,1705
		BE	***0,8723	0,0086	0,1895	0,4356	0,0772	0,2879	-0,3565
			HCO_3	0,3636	0,4394	0,4525	0,3495	0,1399	-0,1405
n = 12				**pO_2**	***0,9088	-0,0929	**0,7448	-0,4211	0,1381
p < 0.05	*	0,5760			**O_2sat**	-0,107	0,5623	-0,2622	0,0222
p < 0.01	**	0,7079				**Na**	0,3545	0,384	0,2422
p < 0.001	***	0,8233					**Mg**	-0,0002	0,2069
								Ca	-0,2655
									Glucose

Tab. 4: Interparameter Correlation Pattern (ICP) of Group Sb (Units like Tab. 1)

pH	***-0,8017	0,4247	-0,1656	*0,5014	**0,5672	-0,3595	0,1738	-0,3501	0,3652
	pCO_2	0,1976	***0,7202	**-0,6168	**-0,6639	0,3195	-0,0067	0,3665	0,3631
		BE	***0,8216	-0,1256	-0,0834	-0,1046	0,2837	-0,0346	-0,0437
			HCO_3	*-0,4350	-0,4328	0,1183	0,1947	0,1877	0,1371
n = 21				**pO_2**	***0,9930	-0,1065	0,1578	-0,1038	-0,274
p < 0.05	*	0,4329			**O_2sat**	-0,126	0,1757	-0,1453	-0,2851
p < 0.01	**	0,5487				**Na**	0,1162	0,3662	0,1371
p < 0.001	***	0,6653					**Mg**	0,3204	-0,274
								Ca	-0,2851
									Glucose

Tab. 5: Interparameter Correlation Pattern (ICP) of Group Sa (Units like Tab. 1)

pH	-0,0206	***0,8071	**0,5759	-0,1188	0,1353	-0,3999	-0,0491	0,0019	-0,1741
	pCO_2	**0,5764	***0,8045	***-0,8058	***-0,8219	0,2612	0,2701	0,2035	-0,2483
		BE	***0,9474	**-0,5739	-0,3752	-0,1743	0,053	0,0971	-0,2123
			HCO_3	***-0,7303	**-0,5916	-0,0257	0,1054	0,1308	0,0758
n = 21				**pO_2**	***0,8933	-0,0351	-0,1747	-0,0741	0,2821
p < 0.05	*	0,4329			**O_2sat**	-0,0248	-0,0389	0,072	0,0141
p < 0.01	**	0,5487				**Na**	0,1918	**0,6405	0,0758
p < 0.001	***	0,6653					**Mg**	0,0544	0,2821
								Ca	0,0141
									Glucose

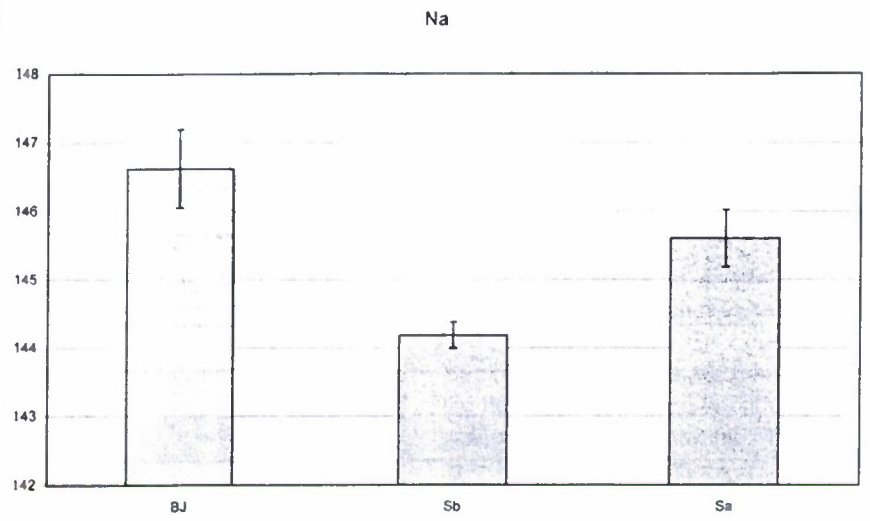

Fig. 1: Abscissa: BJ = Bungee group
Sb = Before ergometry
Sb = after ergometry
Ordinate: Ionized Serum Na in mMol/l

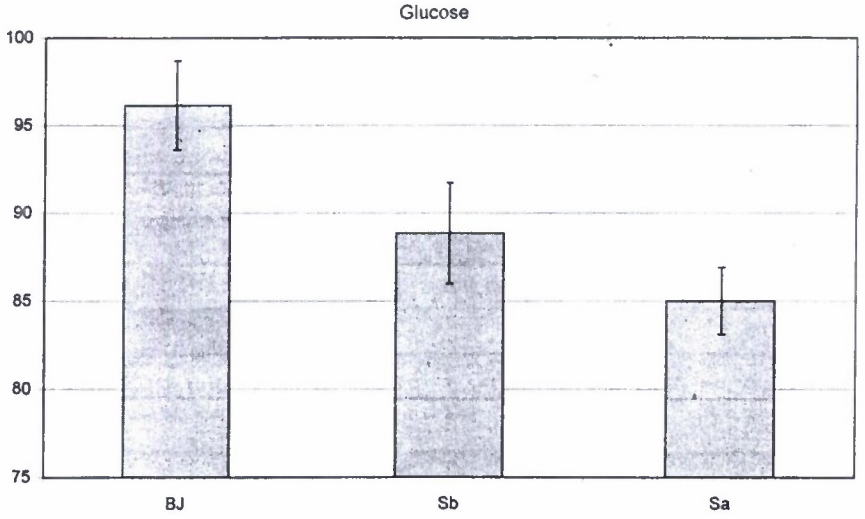

Fig. 2: Abscissa: BJ = Bungee group
Sb = Before ergometry
Sa = after ergometry
Ordinate: blood glucose in mg/dl

unable to exert respiratory eontrol as shown by pH values below 7.3. Concerning electrolytes, the psyehically stressed group showed significantly increased Na levels (Fig. 1) whieh may indieate inereased water loss by inercased breathing frequeney. The same group showed signifieantly higher glueose levels (Fig. 2). This ean be explained by increased glyeogenolysis and increased cateeholamine seeretion which inhibits glueose uptake into myoeytes by inhibition of insulin secretion. Thus even psyehieal stress of a few hours duration leaves the subjeets with inereased glucose and Na levels, both parameters prominently included as risks for isehemie heart disease (*Herold*, 1995). Ca exhibited similar behavior to Na, but there were no significant differences in the average ionized Mg levels between the groups. However, if one looks at the intraparametrie eorrelations within the different groups only the supposedly long term psyehically stressed persons exhibited linear correlations between Mg and pCO_2 as well as pO_2. This may show that intracellular cnergy turnover represented by Mg increase in the blood is forced to progress at the same rate as O_2/CO_2 exehange. This would probably mean that a proeess limiting velocity has been reached, curbing the flexibility of the system. A similar explanation can be attributed to the correlations between BE and pCO_2 and pO_2 within the different groups: only the Sa group, thc subjects of which were not able to eompensate through respiration, showed linear correlations between BE and pCO_2 and pO_2. Consequently, there were no such correlations during resting conditions and sueeessful respiratory control in the psychically stressed group. Summing up the most important results are 1. a eombination of blood gas, electrolyte, and blood glucose determination along with proper statistical evaluation is able to discern psychical from physieal stress and 2. A psyehieal stress contrary to physical stress is characterized by successful respiratory compensation, increased glucose and Na values and evolving linear correlations between Mg and blood gas parameters. Thus psychieally stressed people with increased glucose and Na levels always seem to show linear eorrelations between Mg and blood gas parameters pointing towards restrieted metabolic flexibility.

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Korrespondenz an:
Univ. Prof. *Sepp Porta,*
Institut für Allgemeine und Experimentelle Pathologie, Universität Graz,
A-8010 Graz, Österreich

Discussion: The american standard of 0.25 mmol Mg/l DS in CVVHD results in a great withdrawal of Mg giving even within one day hypomagnesemic levels. But also the european standard of 0.75 mmol Mg/l DS gives a negative Mg-balance, whereby serum-Mg-levels remained within reference values during the study. Although no clinical endpoints were analysed in the present study, data suggest to apply higher Mg-levels of DS to avoid rapid and sharp decrease of serum Mg-levels especially in patients who are electrophysiologically unstable.

*

Magnesium and osteoporosis – hypotheses fingo

K.J. Münzenberg, Bonn

In memoriam Joachim Helbig

It is a physicochemical fact that a molar ratio of magnesium/calcium > 0,2 will prevent apatite formation. The relation is effective in vitro and in vivo. This may become important in the fluor treatment of osteoporosis: In 5–10 % apatite crystals in strained tendons and in joint capsules appear. The administration of magnesium may prevent those precipitations.
Lack of magnesium on the other hand is the cause of lowering of pH in the extracellular fluid of bone, and this may be the reason for the passing supersaturation of the body fluid with octacalcium phosphate. Tissue calcification and undersaturation concerning calcium and phosphate ions in plasma are the result.
These consequenses may be the cause of an excessive secretion of parathomone with consecutive bone loss.
There are 2 possible end-results:
1. The "aplastic bone disease" with subperiosteal hypoplasia and fibrous periosteal tumors, and
2. a generalized loss of bone substance, the osteoporosis.

Until now the one or the other of these consideration is hypothesis, and the realization of it depends on an excessive hypomagnesiemia.

*

Stressreactions in geriatric gymnastics depend upon basal values and serum magnesium dynamics

G. Pinter[1], A. Palasser[3], H. Wiltschnig[3], W. Temmel[1,2], S. Porta[1,2]

[1] Institute of General and Experimental Pathology University of Graz, Austria
[2] Institute of Applied Stress Research, Bad Radkersburg, Austria
[3] Department for Medical Geriatry, State-Hospital Klagenfurt, Austria

27 senior citizens absolving ambulant gymnastics therapy were checked for catecholamines, bloodgases and electrolytes hy blood sampling from an antecubital catheter before and after light gymnastics.
The participants of the test have not been under stationary therapy for at least 3 months.

Results and discussion:
1. the higher norepinephrine basal values, the greater are its alteration due to workload. The same holds true for its effects, like BE or pO_2 alterations.
2. Sorting the patients according to increasing, stable or decreasing serum magnesium, it turned out that the increasing magnesium group mostly had low catecholamine basal values, and a significant better coping with stress. The basal values e.g. in the magnesium increasing group concerning BE were significantly higher, pO_2 was significantly lower than in other groups. Alterations in HCO_3 and pO_2 were significant less pronounced.

*

An attemp to correlate dynamics of ionized magnesium with training status

S. Porta[1,2], W. Temmel[1,2], T. Gifford[1,3], J. Rand[1,3], D. Westmoreland[3], H. Bacher[1]

[1] Institute of Applied Stress Research, Bad Radkersburg, Austria
[2] Institute of General and Experimental Pathology, University of Graz, Austria
[3] Biology Department, US Airforce Academy, Colorado Springs, CO

Aim of the study: In former papers we could show (*Porta* et al. 1997), that some effects of catecholamines, like change in base excess, are linearly proportional to catecholamine levels, and therefore could be used as screening parameters. By measuring 10 different, stress related parameters, we may be able to get a whole pattern of the effects of stresses of different intensity and duration in the more or less immediate past.
Material and methods: Of 26 young volunteers on national service 50 µl of capillary blood were taken just after light gymnastics and 3 minutes of jogging. Bicycle ergometry up to 200 watts (post stress provocation test, *Porta* et al. 1993) was superimposed immediately, followed by a second blood sampling for determination of electrolytes, blood gases and lactate. A group of 20 more volunteers who did not undergo immediate previous stress, but sleep depriving night exercises followed by a field combat maneuver some hours beforehand, underwent the same procedure.
Most important results and conclusions: Ionized Mg was low in the first group and much higher in the second group, a feat not due to diet but to previous stress. Linear correlation between the parameters were the more plentiful, the higher the intensity of accumulated stress has been. Moreover, characteristic stress related interparameter correlation pattern (**ICP**) evolved, whereby Mg played an important role. Consequently, we formed 3 new subgroups, regardless of the previous workload, only characterized by the fact, of an increasing or decreasing or stable reaction of ionized Mg to the ergometric test. Average values, correlation numbers and ICPs pointed to the fact, that the increasing Mg group consisted mainly of subjects in a significant better bodily shape than in the decreasing group.

*

Improvement of feed conversion rate of broilers by Magnesium-L-Aspartate Hydrochloride (MAH)

W. Rattanatayarom, K. Angkanaporn, H.G. Classen

Srinakharinwirot/Chulalongkorn Univ. of Bangkok, Thailand and Univ. of Hohenheim, Germany

Feed Conversion Rate (FCR) describes body weight increase (⌂ g) per (g) feed consumption. It was assumed that Mg improves FCR of broilers and that thyroid hormones might be involved due to their "calorigenic effect" (Schmidt- Thews). To study this hypothesis, 30 about 4-weeks old broilers weighing 778 ± 74 g were randomly allocated to 3 groups of equal size and kept under controlled conditions. The animals received standard feed (66 mmol Mg/kg d.w.) and drinking water enriched with zero, 16 or 32 mmol Mg/L as the MAH (groups 1, 2 and 3, resp.) ad libitum. Treatment lasted 3 weeks; blood was taken from the wing-veins at weeks zero, one, two and three. – Compared to the controls (G 1), weight gain and FCR were significantly improved in group 3. Plasma-Mg significantly increased in G 2 and G 3 while plasma-Ca remained unaffected. T3-levels significantly increased in G 3 compared to the controls; similar tendencies were observed for T 4.
Hence, moderately increased thyroid hormone levels might be one o f the factors that improve FCR in Mg-treated broilers.

*

Magnesiumstatus in diabetes mellitus with bad metabolic control compared to healthy controls

M. Schildheuer, K. Kisters[1], A. Bauer[1], K. Dick, P.M. Rob

Universitätsklinikum Lübeck, Medizinische Klinik I

[1] Medizinische Poliklinik der Universität Münster, Germany

Introduction: There is experimental and clinical evidence giving importance to the relationship between magnesium (Mg) and

diabetes mellitus. It was proposed by the American Diabetes Society to put attention onto the diagnostic of Mg-deficiency in diabetes. Because of regional differences in Mg-supply, we studied Mg-status in the surroundings of Lübeck in healthy persons and in diabetics.
Patients and methods: 27 healthy controls and 27 inpatients with insulindependent diabetes mellitus (DM) and bad metabolic control (CO) were studied. Mg was measured by AAS in serum (S), erythrocytes (Ery): basic 24 h urinary Mg-excretion (b24hMgU), fractionel Mg-excretion (FEMg) were calculated and the Mg-loading (MgLT) test was applied. Magnesiuria was correlated to glucosuria. Measurement. Mean ± SEM; T-Test, $p < 0.05$*.
Results: In diabetics there was hypomagnesemia compared to controls (0.73 ± 0.04 vs 0.83 ± 0.04 mmol/l*) and Ery-Mg was as well significantly lower (1.430.16 vs 1.840.1 mmol/l). B24hMgU was 2.75 ± 3,62 in DM compared to 5.84 ± 2.21 mmol/d* and FeMg 5.83 ± 2.73 in DM and 3.46 ± 1.33 % in CO. The percent retention of the given Mg-load was 24.5 ± 18 in DM and –41 ± 12 in CO**. Glucosuria and magnesiuria were significantly correlated.
Discussion: In DM with bad metabolic control there is convincing evidence of Mg-deficiency. Higher FEMg in case of lower S-Mg indicates an inadequate renal Mg-loss which significantly correlates with the amount of glucosuria as a relevant pathophysiological mechanism. Since we have previously shown in rats that Mg-deficiency may enhance diabetes late complications we suggest to supplement Mg in diabetics to prevent diabetes related late complication.

*

$[Mg^{2+}]_i$ in CA1 neurones of the rat hippocampus

P. Schulte, D. Günzel, W.-R. Schlue

Institut für Neurobiologie, Heinrich-Heine-Universität Düsseldorf, Germany

To investigate the regulation of the free intracellular Mg^{2+} concentration ($[Mg^{2+}]_i$) in rat CA1 neurones, $[Mg^{2+}]_i$ was measured using the fluorescent dye mag-fura-2. All experiments were carried out on 300 µm thick hippocampal slices from 4–6 weeks old Wistar rats.
An increase in the extracellular Mg^{2+} concentration ($[Mg^{2+}]_o$) from 1.3 mM to 30 mM resulted in an increase of $[Mg^{2+}]_i$ and a reversible depolarisation of the cell membrane. These effects may be caused by a reversal of a putative $1Na^+/1Mg^{2+}$ exchanger and/or a passive Mg^{2+} influx into the cells. A subsequent reduction of $[Mg^{2+}]_o$ to 1.3 mM led to a $[Mg^{2+}]_i$ decrease which slowed down with decreasing extracellular Na^+ concentration. This indicates the existence of a Na^+/Mg^{2+} exchanger which, under physiological conditions, extrudes Mg^{2+} from the cell while Na^+ is moved into the cell.
To ascertain that intracellular Ca^{2+} ($[Ca^{2+}]_i$) does not interfere with mag-fura-2, control measurements with the Ca^{2+} sensitive fluorescent dye fura-2 were carried out. The results showed that $[Ca^{2+}]_i$ was almost unchanged under the given experimental conditions and always below 1µM, the critical value for the use of mag-fura-2. The increases in $[Ca^{2+}]_i$ induced by the presence of 30 mM $[Mg^{2+}]_o$ were very small and might be due to a shift in the Ca^{2+} buffering capacity.

*

Serum-magnesium-status and bloodgas changes as differential diagnoses between workload and psychological stress

W. Temmel[1, 2], D. Heidinger[1], A. Kogler[1], S. Porta[1, 2]

[1] Institute of General and Experimental Pathology University of Graz, Austria
[2] Institute of Applied Stress Research Bad Radkersburg, Austria

Aim of the study: The amount of linear correlations between stressindicators like bloodgases, electrolytes and catecholamines increases with increasing workload whereby such steady proportions mostly depict compensation difficulties (e.g. linear pH–BE correlations) especially linear correlations between ionized serum magnesium on the one hand and bloodgases and catecholamines on the other, only develop along with high stress intensities. We investigated, whether those facts were applicable to psychological stresses too.

Material and methods:
1. 21 young healthy males were subjected to bicycling ergometry with blood sampling before and afterwards.
2. A drop of blood was taken from 13 Bungy Jumpers immediately before the jump.
3. 5 patients during therapy for anxiety were tested after climbing 109 steps again after 20 minutes of recreation and again after the slight psychological stress of a biofeedback.

Investigated parameters: catecholamines (only # 1), electrolytes, glucose and lactate.

Results and Discussion:
1. the number of interparametric correlations increases with both increasing physical and psychological load and decreases after recreation.
2. A linear correlation between ionized magnesium and bloodgases evolved only during extreme anxiety before bungy jumping.
3. A decompensated pH–BE correlation can be created not only by physical, but also by psychological stress.

*

An experiment to correct magnesium deficiency in Austrian rural areas by magnesium rich foodstuff

G. Leitner, S. Porta[1, 2], D. Westmoreland[3], M. Knapp[3], K. Spencer[3], J. Merback[3], T. Leitner[2]

Zusammenfassung

15 weibliche Schüler einer ländlichen Haushaltungsschule wurden einer standardisierten Ergometerarbeit unterworfen, wobei vorher und nachher aus Blutproben aus der Fingerbeere Blutgase, Elektrolyte, Laktat und Blutglukose gemessen wurden. Während der folgenden 10 Tage wurde ein stark magnesium- und kalziumangereichertes Essen verabfolgt. Nach dieser Periode fand erneut Blutabnahme und Ergometrie wie vorher statt.

Es zeigte sich, dass eine reichliche Darbietung von Magnesium in der Nahrung gerade im Stande war, den vorher hypomagnesämischen Durchschnittswert des ionisierten Serum-Magnesiums von 0,44 ± 0,01 SEM mM/l auf 0,46 ± 0,01 SEM mM/l anzuheben. Diese Steigerung wäre vermutlich ohne gleichzeitiges Anbieten von stark magnesiumhaltigen Mineralwasser (206 mg Magnesium/Liter) nicht in diesem Maße gelungen.

Offensichtlich ist also einer der wesentlichsten Hinderungsgründe für eine genügende Magnesiumaufnahme aus der Nahrung bei Mädchen dieser Altersgruppe eine starke Tendenz zur Nahrungskarenz aufgrund falsch verstandener Schönheitsideale.

Obwohl sich keine diätbedingten Änderungen in den Mittelwerten der Blutgasparameter nach der Ergometrie zeigten, traten nach der Diätepisode individuelle Proportionalitäten zwischen Baseexzess und pH, Baseexzess und Laktat, nicht aber zwischen Laktat und Baseexzess hervor. Aus diesem Verhalten vermuten wir eine lipolysesenkende Wirkung der erhöhten Magnesiumzufuhr nur bei jenem Teil der Probanden, die ausreichend magnesiumreiche Nahrung zu sich genommen hatten. Aufgrund dieser Ergebnisse empfehlen wir eine niederkalorische Magnesiumsupplementation bei Mädchen dieses Alters.

[1] Institute of Applied Stress Research, Bad Radkersburg, Austria

[2] Institute of Pathophysiology, Karl-Franzens University, Graz, Austria

[3] Biology Department, USAF Academy, Colorado Springs, Co., USA

Summary

15 female students of a rural agricultural school have been subjected to a standardized cycle ergometry, whereby blood gases, electrolytes, lactate and blood glucose were measured before and after exercise. During the following 10 days a calcium and magnesium enriched diet was provided and afterwards the same blood sampling and ergometry exercise was carried out once more.

It turned out, that a magnesium enriched diet was just able to increase the average, hypomagnesemic ionised serum levels (from 0.44 ± 0.01 SEM mM/l to 0.46 ± 0.01 SEM mM/l). Even that would have been to no avail, unless a magnesium rich mineral water (206 mg of magnesium/l) would have been offered at the same time. Obviously, the most important prohibiting factor for a sufficient magnesium intake in the female age group of about 16 is a general avoidance of food in order to reach or keep up slenderness.

Although there were no diet induced alterations of the averages of blood gas reactions to ergometry to be seen, ensuing proportionalities of individual base excess and pH, base excess and lactate, but not lactate – pH values suggest a decreased lipolysis after increased magnesium diet in those participants with sufficient uptake [1, 2]. A low calory magnesium supplement has been recommended.

Introduction

In a former paper, a surprisingly low level of ionized serum magnesium, especially in Austrian female high school students of about 17 years of age within an urban environment has been reported [3].

Since the opportunity arose to check the same parameters of a similar collective within the more controlled circumstances of a rural boarding school, we were basically interested, whether rural environment would bring about different feeding habits. Moreover, the teaching staff agreed to provide the girls with a specially cooked magnesium rich diet, the possible effects of which upon electrolyte levels and performance parameters we could check by testing electrolytes, blood gases, lactate and blood sugar before and after the dietary intervention, both, with and without physical workload.

Materials and methods

15 female students of the Halbenrain – agricultural housekeeping – boarding school, with an average age of 16, were subjected to a standardized ergometry program (Ergo-Line, Ergo-Metrics 800S). The program was nine minutes in duration, consisting of three, three-minute intervals of controlled power output of 50 watts, 100 watts, and 150 watts, respectively. The intervals were completed in sequence and without resting between them.

Before and after ergometry, three drops of capillary blood were drawn from the fingertip for determination of lactate (Boehringer-Mannheim) (mM/L), glucose level in blood, pH, partial pressure of carbon dioxide (pCO_2) (mmHg), base excess (BE) (mM/L), hydrogen carbonate (HCO_3) (mM/L), parital pressure of oxygen (pO_2) (mmHg), and percent oxygen saturation (O_2sat) (AVL Compact 3) as well as ionized sodium (Na) (mM/L), ionized magnesium (Mg) (mM/L), and ionized calcium (Ca) (mM/L) (AVL 988-4).

During the ten days following the ergometry program, the meals fed to the subjects were prepared with a high Mg and Ca content.

Tab. 1: Magnesium uptake during ten days of magnesium enriched diet.

Calculated Mg uptake per day and person in mg	Food magnesium contents without mineral water in mg	Magnesium uptake by mineral water per day and person in mg	Percent of magnesium uptake by mineral water
468	396	72	15.83
156	86	70	44.87
238	173	56	23.52
201	125	76	37.18
212	156	56	26.41
302	208	94	31.12
256	206	50	19.53
120	84	36	30.00
205	169	36	17.56
234	140	94	40.17
226	118	108	47.87
385	299	86	22.34
323	193	130	40.25
256	184	72	28.12
278	216	62	22.30
257.33	**183.50**	**73.2**	**28.45 mean**
87.18	80.53	26.03	11.29 **SD**

As an example of the menu, we randomly choose the food arrangements of day 1 and day 7:

Day 1:

Breakfast: coarse whole meal roll, butter, jam,

2^{nd} *breakfast:* buttermilk, rye bread, cheese, fruit.

Lunch: Liver dumpling soup, turkey-roast with "dinkel" whole grain rice, green salad, yogurt creme with fruits.

Dinner: Vegetable salad and cheese and olive dressing, rye bread, herbal tea.

Day 7:

Breakfast: Fresh home made muesli and fruits,

2^{nd} *breakfast:* buttermilk, rye bread, cheese, fruit.

Lunch: Chicken soup, Roast chicken with full grain rice, mixed salad, rhubarb cake made from whole meal.

Dinner: Sweet "dinkel" semolina pancakes, stewed apples.

A mineral water with 206 mg magnesium per litre was available ad libitum. The subjects kept a daily log of all the food and mineral water they consumed during the course of the experiment.

Tab. 2: Means and SEM of all the parameters measured before and after workload and diet.

	pH	PCO_2	BE	HCO_3	pO_2	O_2sat	Na	Mg	Ca	Lactate	BS
1-Pre	7.417	34.97	–1.31	21.83	65.91	91.71	142.21	0.44	1.30	1.47	86.13
SEM	0.006	0.81	0.39	0.41	2.95	1.28	0.60	0.01	0.01	0.16	3.84
1-Post	7.343	29.28	–8.29	15.55	82.99	94.81	141.98	0.43	1.29	6.23	70.47
SEM	0.012	0.63	0.81	0.64	1.86	0.35	0.39	0.01	0.01	0.68	1.99
2-Pre	7.408	35.52	–1.71	21.77	69.01	92.91	141.11	0.46	1.30	2.13	88.13
SEM	0.009	1.02	0.62	0.63	2.72	0.65	0.69	0.01	0.01	0.32	3.44
2-Post	7.353	29.19	–7.79	15.83	85.20	95.37	140.37	0.43	1.28	7.04	74.20
SEM	0.012	0.96	0.80	0.70	2.12	0.22	0.37	0.01	0.01	0.68	2.78

After the 10 days nutrition regimen the subjects performed the same standardized ergometry training. The same procedure for collection and analysis of the blood was followed. All participants gave their written consent according to the Helsinki Charter, being fully aware of the nature and purpose of the experiment.

Results

1. Calculation of individual magnesium uptake by both food and mineral water:

Mg uptake per day and person was calculated according to the magnesium contents of the foodstuffs and the amount of their uptake (Tab. 1).

Although in the average little more than 300 ml of mineral water had been drunk each day, the average percentage of daily magnesium uptake by water ranged from 15 % to 47 %.

2. Measurement of blood gases, blood glucose, lactate and electrolytes:

Average values for blood gases, blood glucose, lactate and electrolytes were calculated before and after ergometry on both days. There was a statistically significant increase in basal Mg levels ($p = 0.0293$) from Day 1 to Day 2. From this higher basal level on Day 2 we also witnessed a decrease in the post-ergometry Mg (Fig. 1, $p = 0.0511$).

On Day 2, we saw a significant decrease in the post-ergometric Na as compared to Day 1 (Fig. 2, $p = 0.0011$).

Ca significantly decreased following ergometry on Day 2 only (Fig. 3, $p = 0.0329$).

The average pH decreased significantly on both days following ergometry. ($p = 0.0003$ and 0.0022 resp.). Lactate experienced increases in post-ergometry values, as should be expected. Additionally, the resting lactate on Day 2 was almost significantly higher (Fig. 4, $p = 0.0513$) than on Day 1. Blood glucose significantly decreased following ergometry on both days ($p = 0.0006$, $p = 0.0006$), and base excess

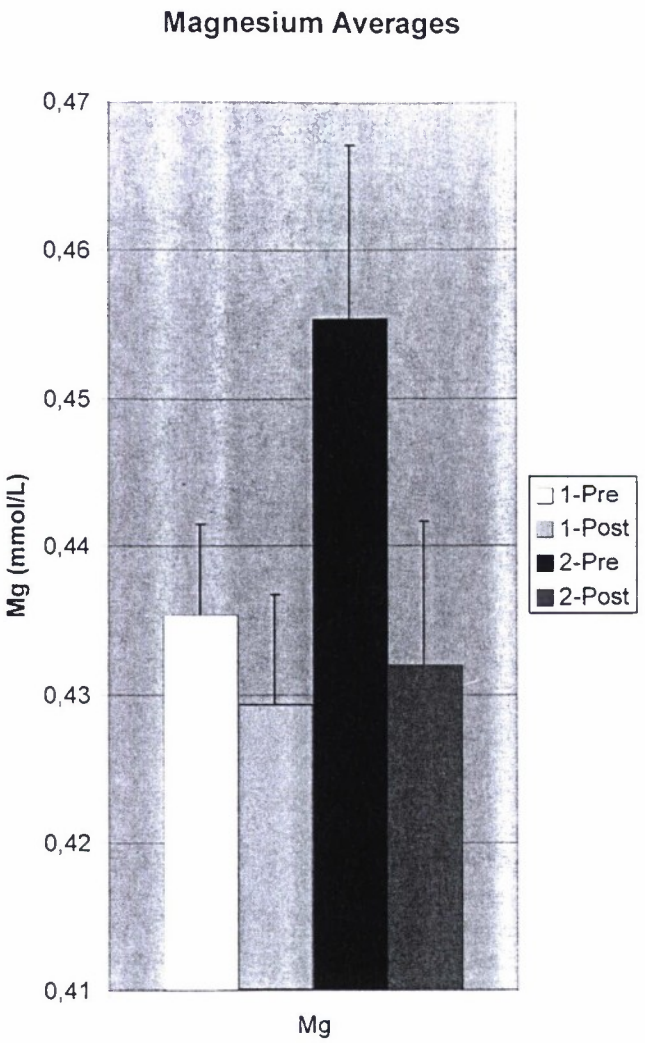

Fig. 1: Ionised magnesium before and after ergometry with and without magnesium-enriched diet.
Abszissa: 1-Pre: Before ergometry without diet
1-Post: After ergometry without diet
2-Pre: Before ergometry with diet
2-Post: After ergometry with diet
Ordinate: mmol/l magnesium

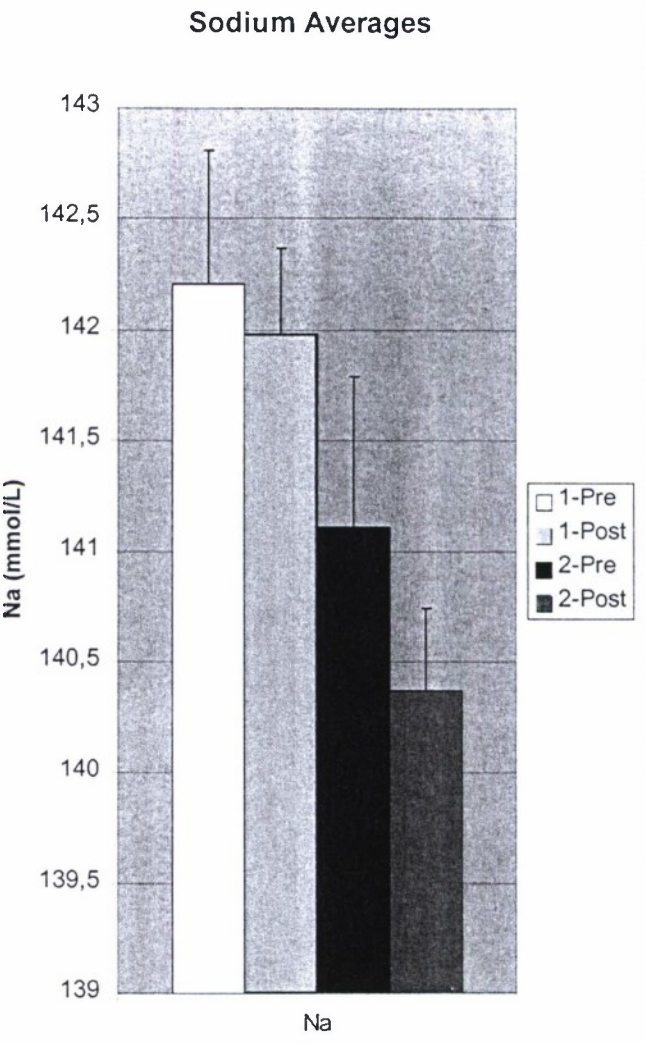

Fig. 2: Ionisod sodium before and after ergometry with and without magnesium-enriched diet.
Abszissa: 1-Pre: Before ergometry without diet
1-Post: After ergometry without diet
2-Pre: Before ergometry with diet
2-Post: After ergometry with diet
Ordinate: mmol/l sodium

significantly decreased ($p < 0.000001$, $p < 0.000001$).

Blood gas parameters, as pH, pCO_2, BE, HCO_3, pO_2 and O_2sat did not show any significant differences in their average values which could be attributed to the dietary changes (Tab. 2).

However, there was a marked difference concerning the linear relationships pH-BE-lactate between the different sampling times:

Before ergometry on day 1 no significant linear correlation between pH, BE or lactate could be seen. After ergometry a linear relationship between pH and BE evolved.

On day 2, a significant linear correlation between pH and BE was already present before ergometry. After ergometry BE values did not only correlate linearly with pH values, like on the first day, but also with lactate values. There was however no correlation between pH and lactate values at this time.

Discussion

In a former paper [3] we could show, that Austrian youngsters, especially females around the age of 16 show a remarkable lack of serum magnesium, shown by determination of ionized serum magnesium with and without ergometrical workload, thus ruling out possible hazards in determining false positive or negative basal values [3].

Shortly afterwards, we were given the opportunity of not only being able to check on the magnesium dynamics of

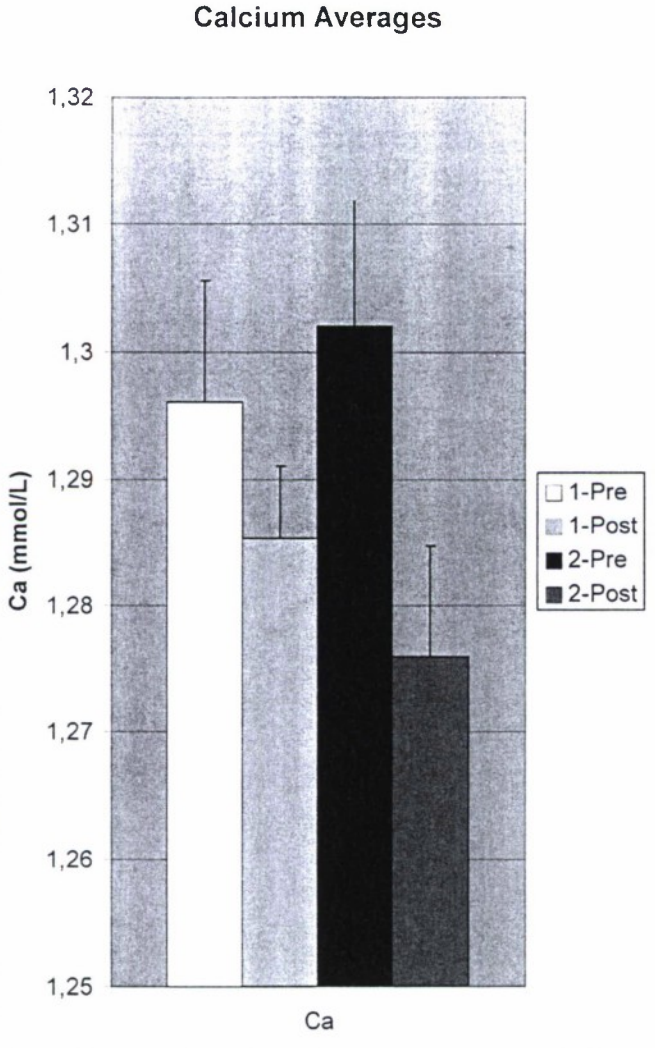

Fig. 3: Ionisod calcium before and after ergometry with and without magnesium-enriched diet.
Abszissa: 1-Pre: Before ergometry without diet
1-Post: After ergometry without diet
2-Pre: Before ergometry with diet
2-Post: After ergometry with diet
Ordinate: mmol/l calcium

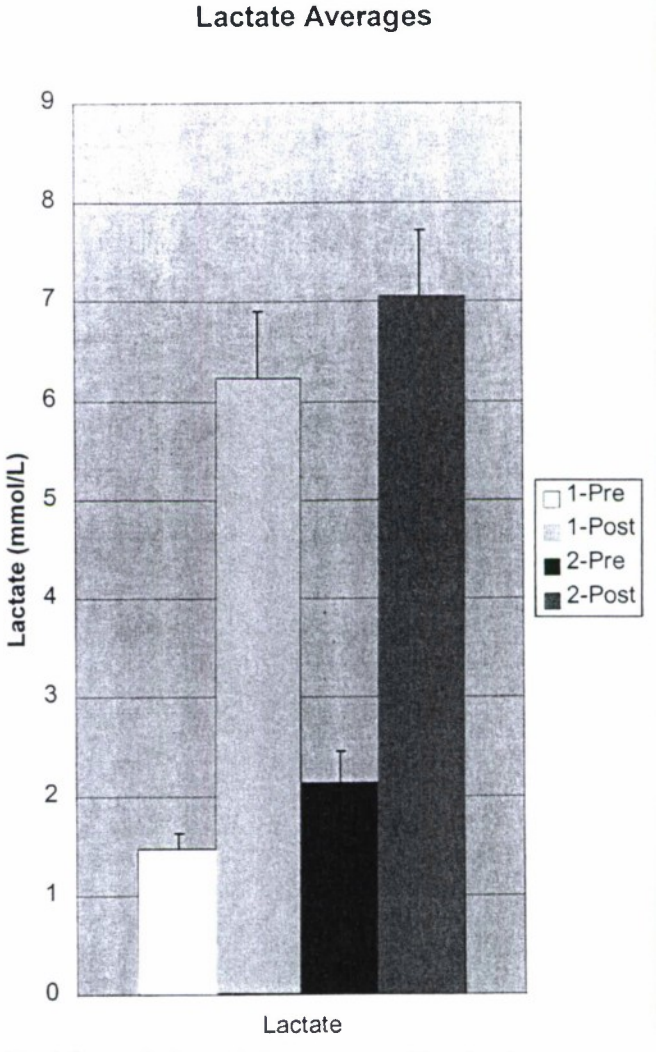

Fig. 4: Lactate before and after ergometry with and without magnesium-enriched diet.
Abszissa: 1-Pre: Before ergometry without diet
1-Post: After ergometry without diet
2-Pre: Before ergometry with diet
2-Post: After ergometry with diet
Ordinate: mmol/l lactate

a similar group of young females, but, since they were attendees of a housekeeping boarding school, we were offered by the head and staff of the school that an attempt would be made to offer to our probants during 10 days a specially cooked diet of uncommonly high magnesium and calcium content.

Although – as one can see from the menu samples in material and methods – every effort was made to cook a very palatable food, it lay in the nature of the females of about 16 that food uptake in general (with a few exceptions) was sparing. Thus, in spite of the high magnesium contents of the meals, only about 30 % of the girls ingested a total of more than 300 mg magnesium per day. Moreover, of the total average uptake of about 257 mg of magnesium, about 73 mg or about 28 % (!) was due to ingestion of a particularly magnesium rich mineral water (206 mg/l).

It does not seem highly speculative, if we estimate the normal magnesium intake in form of foodstuffs of an average 16 year old Austrian girl, without carefully selected food and without special mineral water supplement far below the average mark in this paper.

However, even a purposely magnesium enriched diet did only just increase the probants' ionized serum magnesium from clearly hypomagnesemic basal levels [6] of 0.435 mM/l to 0.46 mM/l, a level slightly above the necessary 0.45 mM/l, whereby still about half of the girls remained hypomagnesemic. Still, the regimen resul-

ted in a significant increase of ionized serum magnesium within only 10 days of a high – magnesium diet. Ergometric workload did decrease ionized serum magnesium concentrations again, whereby we got the impression, that the girls were very hard put to go through the whole ergometry procedure, which points towards a rather poor bodily condition, possibly at least party due to the lamentable magnesium state.

Similar to the dynamics of magnesium, which showed significant differences before and after workload after only 10 days of diet, calcium levels were likewise only significantly different due to workload after, but not before the diet period.

Serum sodium levels decreased markedly from the beginning of the experiment towards its end. Since we did not calculate the sodium contents of the diet, we cannot explain this fact. We presume however, that sodium chloride was more sparingly used while preparing a "diet".

Beyond the significant differences in electrolytes, there were – with the exception of a slight but significant increase in basal lactate after the diet regimen – no diet attributable differences in the average values of blood gases and blood glucose before or after exercise, so that basal magnesium changes were most probably not due to different stress levels but to real dietary effects.

But if one looks at the proportional relations between the individual pH and base excess values at first no significant linear correlation between those two parameters under basal conditions is to be discerned [4, 5]. After workload however, a linear proportion develops between pH and base excess, probably meaning that buffer capacity does not suffice any more to keep blood pH unscathed by the developing metabolic acidosis.

After the 10 days of diet, a significant linear correlation between pH and base excess exists already before workload has been applied. After workload, an additional linear correlation between base excess and lactate ensures. However, increase in magnesium levels is known to decrease lipolysis, perhaps even via magnesium induced influence upon catecholamine turnover [1, 2].

Since there is no correlation between pH and lactate after the diet period, neither before or after workload, it is not impossible that in those 30 % of the participants, with sufficient magnesium uptake lipolysis is less expressed, while lipolysis in those with particularly poor food uptake is still high. Therefore a general proportion between pH and lactate could not be established.

In conclusion, a very skillfully cooked diet along with ample mineral supplement may well be able to increase the lamentable low magnesium levels, especially of our female youngsters, but it remains to be seen, how far an average family would be able to imitate the professionality of a housekeeping school. Even if one would succeed in doing so, the overwhelming tendency for slimming down in this age group would probably prohibit satisfactory food uptake and thus jeopardize the whole effort. Therefore any kind of magnesium supplementation, preferably in a low caloric form is suggested.

The authors would like to thank the enthusiastic young probants of the St. Martin school at Halbenrain and their highly cooperative staff of teachers. They are especially indebted to Mrs. *Leopoldine Tschiggerl*, headmaster, for the idea to this paper and fantastic food.

The help of Mrs. *B. Poncza*, Mrs. *P. Porta* and Mr. *T. Porta* is appreciated, as well as the work done by the students of the Endocrinology Seminary.

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Correspondence to:
Sepp Porta
Institute of Applied Stress Research
Hauptplatz 2–4, A-8490 Bad Radkersburg
E-Mail: stresscenter@netway.at

Memorandum of the participants of the International congress for the assessment of stress intensity and stress compatibility in large groups

A considerable number of presentations at the "International congress for the assessment of stress intensity and stress compatibility in large groups" deals with the effects of magnesium in stress. To underline this important role of magnesium, the attendees have agreed to sign a memorandum aimed towards the providers of magnesium measuring equipment, encouraging them to create equipment standardization to promote comparability of data and thus a more general acceptance of ionized magnesium measurement. Magnesium Bulletin has generously agreed to publish the memorandum along with the congress abstracts. Readers who want to further comment the memorandum, are encouraged to do so on the website: www.bro.at/congress or to contact the editors of Magnesium Bulletin.

S. Porta

... therefore, the measurement of ionized magnesium does not make sense, perhaps with the exception of...hypoproteinemia.

(Klaus Dörner, in "Labor und Diagnose", by L. Thomas, p 348, TH-Books, 1998.)

Determination of ionized magnesium is simple, hardly invasive, sensitive, cheap and can be performed by comparatively unskilled personnel with transportable equipment.

Determination of total and bound magnesium cannot be performed on the spot and needs time and a laboratory.

On the other hand, determination of ionized magnesium alone is impracticable, as K. Dörner rightly states. An epidemiological survey of ionized magnesium in large groups may just have its merits, but measurement of magnesium status in individuals by determination of basal values of ionized magnesium alone is impossible, because:

1. Moderately increased magnesium uptake is not necessarily followed by an increase of the ionized fraction, but rather by an increase of the bound fraction.
2. Only appreciably increased magnesium uptake may also increase the ionized fraction.
3. However, an increased ionized fraction often follows stress induced cell depletion of magnesium.

Therefore, a differential diagnosis of the circumstances in which certain levels of ionized magnesium occur is inevitable.

In general, the determination of increase or decrease of ionized magnesium before and after acute exercise could already give some idea of the origin of high or low basal values.

Moreover, simultaneous determination of ionized magnesium and other easily and cheaply measurable on-the-spot parameters such as blood gases, lactate, glucose, amino acids and white blood cell numbers and function, could characterize the stress status at sampling time and therefore be helpful for differential diagnosis.

A determination of ionized magnesium within these paramcters seems to make sense since, together with ionized magnesium, they would mutually describe and support each other's position. This information could then be used for the assessment of the stress status of an individual, and could be much more useful and informative than a mere electrolyte determination.

Possibilities for the application of this method – beyond the scope of basic research – could include sports medicine, ancillary data for psychological assessments, defense medicine, preventive medicine, space medicine, gerontology, prognostic medicine, food and health science, objective assessment of the outcome of health cures and much more.

This may open a much wider market for manufacturers of magnesium electrodes, who, up to now, mostly catered for intensive care units and basic and applied research laboratories.

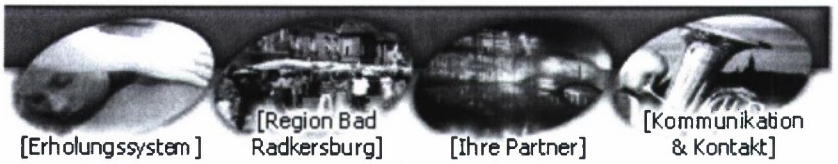
However, disagreement about the validity of data produced by different equipment from different manufacturers has considerably prohibited research into ionized magnesium, because data obtained with one make of equipment has been regularly criticized by users of the other. This attitude is still prohibiting world wide acknowledgement of the merits of ionized magnesium assessment, which could – within the borders sketched above – be beneficial for lot of different applications.

A national consensus about high and low margins of ionized serum magnesium, was set up in Germany and Austria. However, it was not very helpful, since the multinational manufacturers continue to disagree about

calculation quotients or modes of comparison between their products.
Discussion about critical high or low margins may even not be too important, since it was recently shown that knowledge about the dynamics of ionized magnesium may be of higher diagnostic value than evaluation of basal concentrations.
Therefore, slight differences in absolute values, obtained using different equipment may be even less important in the future.

In conclusion, for the benefit of magnesium research, an agreement should be sought between all electrode manufacturers. This would encourage them to introduce acceptable data transformation systems into their equipment which would render all ionized magnesium measurements comparable, regardless of the measuring apparatus.
Such an agreement would immediately increase world wide acceptance of the measurement of ionized magnesium; scientists as well as manufacturers would benefit.

Bacher, Dr., Boehmer, Dr., Bradshaw, Col., Dr., Bruggraber, Dr., Castell, Dr., Bailey, Dr., Doder, Dr., Fleck, Dr., Frise, Brig. Gen., Dr., Harer, Dr., Hueber, Mag., Kaciuba-Uszilko, Dr., Kim, S. W. Col., Kollmann, Dr., Larsson, Dr., Marktl, Dr., Nazar, Dr., Palasser, Dr., Pfannhauser, Dr., Pinter, Dr., Porta, Dr., Rowe, Dr., Seelig, Dr., Seidl, Dr., Smolle, Dr., Temmel, Dr., Wieltschnig, Dr., Zaruba, Dr., Zollner, Dr.



Congress for the assessment of stress intensity and stress compatibility in large groups

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International congress for the assessment of stress intensity and stress compatibility in large groups in Bad Radkersburg from November 25th to November 27th 1999.

We wish to thank the following for their contribution to the success of this conference:

European Office of Aerospace Research and Development, Air Force Office of Scientific Research, United States Air Force Research Laboratory

Aim of the Congress:

1. Measurement of stressor impact is traditionally carried out by plasma catecholamine determination.
   Difficulties with time consuming and invasive blood sampling, need of stationary sophisticated equipment, need for highly qualified personnel, transport problems and cost of analyses prevent large group testing, thus seriously curbing progress of applied stress research.
2. Development of less invasive and less costly methods, transportable equipment, use of "post stress provocation tests" for estimation of stress in the immediate past and combined serological and psychological method together with pattern recognition research may forge a tool useful for large group testing.
3. Along those lines, the usefulness of supplementation with "high turnover substances", like magnesium or glutamine before and during stress situations should be discussed.
4. Scientists, who want to contribute to those topics are invited to **submit their abstracts using this form** or mail them to **stresscenter@netway.at** , including some biodata

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International Congress

For The Assessment Of Stress Intensity And Stress Compatility In Large Groups

Bad Radkersburg, November 25th - 27th